Power Proficient Corona Deployment Strategy for Wireless Sensor Networks

Meenakshi[1] Kirti Bhatia[2] Shalini Bhadola[3] Rohini Sharma[4]
[1]Student [2,3,4]Assistant Professor
[1,2,3]Sat Kabir Institute of Technology and Management, Haryana, India [4]Government PG College for Women, Rohtak, India

Abstract— The Wireless Sensor Networks (WSNs) is an area of emerging technology which involves numerous number of sensor nodes/motes, a base station, processing power and storage. However, these have very limited power. The nodes exchange data and control messages with each other and towards the base station to fulfill a sensing and monitoring process. In present work, we have suggested a deployment strategy which improves lifespan of the network and also makes balanced consumption of energy during transmission process. We have employed Non-uniform corona protocol and equated with standard Low Energy adaptive clustering hierarchy (LEACH) protocol. Experimental outcomes exhibits that, Non-uniform corona protocol improves the lifetime of WSN and the amount of work accomplished in the network by this protocol is much more than the conventional LEACH protocol.

Keywords: Sensor Networks, Stability, Non-Uniform Corona, Lifespan, Deployment Strategy

I. INTRODUCTION

As an icon of the new generation of sensor networks, the WSN is a dispersed self-forming architecture which incorporates data procurement, handling and transmission operations [1]. It has a widespread variety of applications in various significant areas, like cultivation, transport, and soldierly. Generally, the motes are operated with little battery power [2-3], thus the objective of prolonging the lifespan of the WSN may be accomplished through reduction of unnecessary power depletion [4]. There is a need of an effective technique which can reduce power consumption of the network [5-6]. Effective placement of wireless sensor nodes is of paramount importance as the lifetime of the network depends upon it. In this work, a corona based energy balanced node deployment scheme for sensors with a limited sensing range has been proposed in which the nodes are distributed in accordance with a probability density function (PDF). Optimal number of nodes in each corona has been placed region wise. Performance of the scheme is evaluated in terms of coverage, energy balance and network lifetime through simulation. It is noticed that the node distribution through the proposed scheme not only provides better coverage in each layer but also minimizes both the energy-hole and the coverage-hole problems in the deployment field while maintaining longevity of the sensor network.

The position of SNs has tremendous impact on the performance of the WSNs. The choice of the node deployment scheme depends upon the metrics such as connectivity of the network [7], full area coverage [8] and remains unchanged throughout the lifetime of the network. A significant problem receiving large consideration recently is the coverage along with connectivity problem [9]. This emphasizes on how effectively the wireless sensors monitor the physical surroundings and also communicate the sensed data to the BS. The area covered by a sensor node is known as its sensing area. When two SNs lie within the transmission range of each other and can communicate, it can be said that the two nodes are connected. The sensing and communication domain of a SNs are closely related. Therefore, these two parameters are essentially considered in the deployment of SNs in the WSN. Each sensor node dissipates energy in sensing and communicating the data to the BS. Therefore, energy is the most important constraint in WSN. Deployment of SNs and location of the BS has a vital role in increasing the life of the WSN. The multi-hop communication is more energy efficient in terms of lifetime of the network as compared to direct communication. In the case of multi-hop communication the energy depletion rate of nodes placed near the BS is higher as compared to the distant nodes. Energy-hole [10] can be created if the nodes near the BS die out early as compared to the distant nodes. Many researches have been carried out in this area and non-uniform node deployment [11] is considered to be the best strategy to eliminate energy-hole issue. In this type of node deployment maximum numbers of nodes are placed towards the BS and decreases as the distance from the BS increases. These deployed nodes can handle the traffic flow and avoid the energy-hole in WSNs.

In this paper, a non-uniform corona based energy balanced node distribution (ND) scheme is proposed that contributes to better coverage and an energy-efficient communication even when SNs are limited in sensing range. The paper is organized as follows: Sect. 2 discusses the existing literature survey regarding various node deployment schemes. The problem is described in Sect. 3. The energy model is discussed in Sect. 4. Section 5 presents the description of the proposed scheme. Section 6 discusses the proposed protocol. In Sect. 7, the performance of the proposed scheme is evaluated quantitatively and qualitatively. Finally, Sect. 8 concludes the work done.

II. RELATED WORK:

Conserving energy has been fundamental issue in WSNs. Many research have been reported in order to avoid energy-hole problem and maximizing the network lifetime in WSNs. Authors in [12] discuss about the lifetime of WSN in detail. Here, the authors present the lifetime as a measure of the number of alive nodes, coverage, connectivity, both the connectivity and the coverage and many others. Various parameters that affects the lifetime of WSN are also discussed in their work. Yetgin et al. [13] discuss v:arious techniques that maximizes the lifetime of the network. They are namely: optimal node deployment, routing, data co-relation and many others. We propose a corona based node deployment scheme that not only balances the energy across the network but also provides better coverage and connectivity in WSN thereby maximizes the network lifetime. Hence, the literature is surveyed regarding deployment schemes, network connectivity and coverage in WSN. Rahman et al. [14] classify the deployment scheme into two: non-corona and corona based strategies.

The non corona based strategies are distinguished into random Gaussian and random uniform. Here, random means the nodes are dropped by helicopter and uniform means that the nodes density is uniform across the network in deployment field. The authors in [15] use random deployment strategy to deploy SNs. Additional SNs were deployed to achieve maximum coverage. The drawback is the decreased lifetime due to unbalanced energy consumption in the network. In [16], the authors present a mathematical calculation based on which the number of nodes in each corona is placed. Hence, the density of the nodes is decided based on the communication range of each sensor. This approach creates an energy-hole problem in the innermost corona. Similarly, in [17-18] the authors propose the node deployment scheme with the objective to achieve full coverage with minimum number of SNs. In [19], the authors propose a node deployment scheme that uses the minimum number of nodes and provides full coverage of the network field. However, such an approach cannot be realized in some application such as battle field and habitat monitoring.

III. PROBLEM DESCRIPTION:

In the proposed solution, the deployment area has been partitioned into various concentric coronas and the sink is positioned at the middle of the area. The thickness of all coronas has been kept constant and it is same as the radius (R) of the innermost corona. Henceforth, starting from the BS, the region of each corona enhances in arithmetic progression with the mutual difference of $2\pi R^2$. The previous researchers have focused on avoiding the existence of energy hole and coverage-hole in constant width corona centered network design. In pursuance of attaining efficient energy network, the sensors are disseminated in such a manner that the node density remains thick around the sink node of the network.

A non-uniform node distribution is most commonly applied to prevent the existence of energy holes in the sensor network in such a manner that the largest numbers of sensors are positioned in the innermost corona around the sink node and afterward it reduces to the outer coronas. This type of distribution is beneficial in evading the energy-hole situation in WSN.

Though, in some circumstances like restricted sensing range the number of sensors required to cover the successive coronas should increase from inner corona to outer corona to avoid occurrence of coverage holes. Consequently the area of all coronas escalates in the uniform width corona centered network design. Henceforth for evading energy-hole, the node density must reduce from inner to outer coronas while for evading coverage-holes the node density must enhance from inner to outer coronas. Also, these restrictions have a reverse association with each other with reference to node density. All these prevailing approaches suggest that if node density drops then area of each corona increases. Henceforth, the combination of both the non-uniform node distribution and the uniform width coronas are not able to bestow an appropriate choice to evade both the energy and the coverage hole throughout the network. Consequently, in this work we have projected a node deployment strategy which employs network architecture with reduced corona width. When sensor nodes are deployed non-uniformly in decreasing width corona centered network design, the sensing coverage of the positioned sensor nodes overlap more to outer coronas. It lessens the need of sensors to be distributed in the outer corona and provides better coverage.

The goal of this work is to provide a non-uniform deployment of sensors in a corona centered design with a restriction of sensor nodes with inadequate sensing abilities. In the proposed varying width corona based network architecture, the deployment area has been partitioned in such a manner that the region of every corona is same but distribution of nodes is not uniform in all coronas. This type of network design for node deployment can support better coverage, evade the existence of energy-hole and also equalize the energy depletion throughout the network. Let, Rs and Rc are the sensing and communication range of a sensor respectively as shown in figure 1.

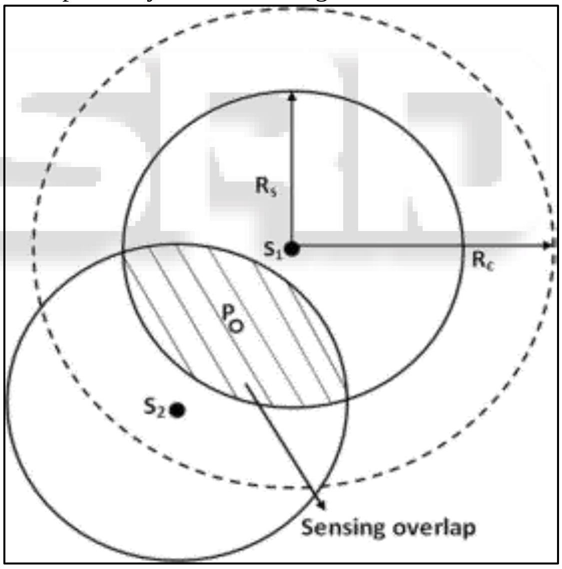

Fig. 1: Sensing and Communication Range of a Sensor

IV. ENERGY MODEL:

The model used in LEACH protocol has been followed in our method using equation 1 and 2:

$$E_{TX}(k,d) = \begin{cases} k * E_{elec} + k * \varepsilon_{friss-amp} * d^2, d < d_0 \\ k * E_{elec} + k * \varepsilon_{two-ray-amp} * d^4, d \geq d_0 \end{cases} \quad (1)$$

$$E_{RX}(k) = E_{elec} \times k \quad (2)$$

The E_{Tx} and E_{Rx} are powers disbursed during transmission and acceptance of a data packet correspondingly.

- Data rate of every single sensor node is given by k (in bits/sec). When the distance d is relatively far-away, the multiple-path fading channel model (d^4 power loss) is used otherwise free space model (d^2 power loss) is used.

- E_{elec} is the radio energy dissipation, used to activate the transmitter and receiver circuit board.
- ε_{fs} and ε_{amp} are amplifier energies, the energy required by power amplification to achieve an acceptable bit error rate in the two models.

V. PROPOSED SOLUTION:

The paper proposes a non-uniform corona centered node deployment technique which distributes sensors with variable concentrations in the applicable deployment/network area to successfully address the problems of energy and coverage holes. The network area has a sink node at the center. The network area has been divided into a number of concentric circles. All the coronas have same area but nodes are concentrated near the sink. This type of distribution eliminates energy holes problem in the network as the most of the number of nodes are deployed in the sink area. The nodes are dispersed through the suggested node deployment procedure that allocates the nodes non-uniformly in all coronas with the aim of improved coverage and removal of energy-hole thereby, extending the lifespan of the network.

VI. THE NETWORK MODEL:

Considered deployment field is assumed to be square shaped having an area of M X M units square with sink located at the center of the field as shown in Fig 2. The network field has been partitioned into equal sized coronas.

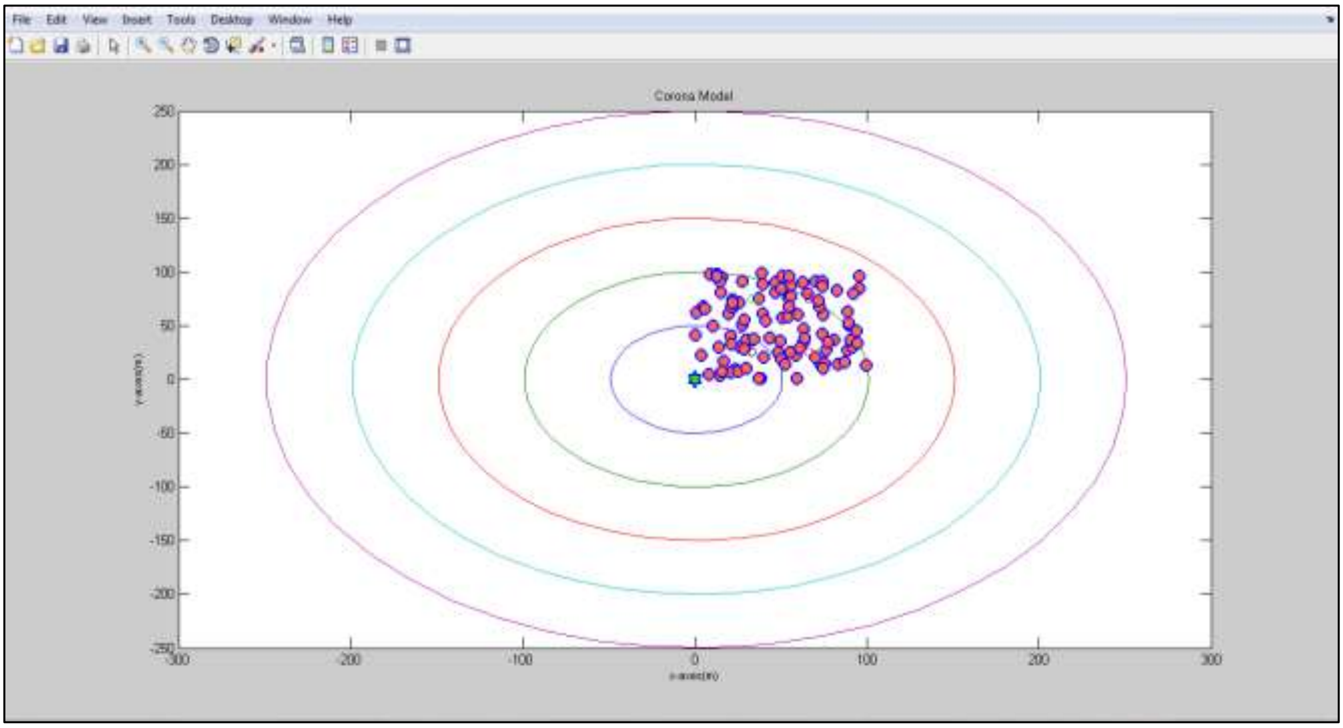

Table1 describes the simulation parameters used in the network. We have used MATLAB for simulations. The used sensors are static by nature.

Parameters	Value
E_{init}	0.5 J
E_{elec}	5 nJ/bit
E_{fs}	10 pJ/bits m^2
E_{mp}	0.0013 pJ/bit/m^4
E_{DA}	5 pJ/bit
Initial energy of advanced nodes	E_{init} (1+β)
Data Aggregation	0.75

Table 1: Parameters and their values

VII. ANALYSIS OF NETWORK LIFESPAN:

The analysis of the network has been done for the total number of sensors in the network and is as discussed as follows:

The Network lifetime is expressed as the period from the start of the network until all the sensors in any corona expires such that an energy-hole is formed in the network. The Node density is expressed as the ratio of the number of sensors disseminated in a corona and the area of that corona. The Data transmission rate of the i^{th} node in the j^{th} layer can be expressed as the ratio of the data produced in the i^{th} layer to the node density in that layer.

VIII. RESULTS:

Figure 1 depicts the total number of nodes per cycle in the network. It has been analyzed that distribution of nodes improves the performance of the network. The power balancing balance the energy consumption of all layers; so that the network lifetime of all layer can be increased. In sensor network the energy is balanced in the network if all the nodes finish their energy simultaneously. Figure 2 shows the number of alive nodes in the network per cycle. Figure 4 and 5 give a clear description of energy in the network.

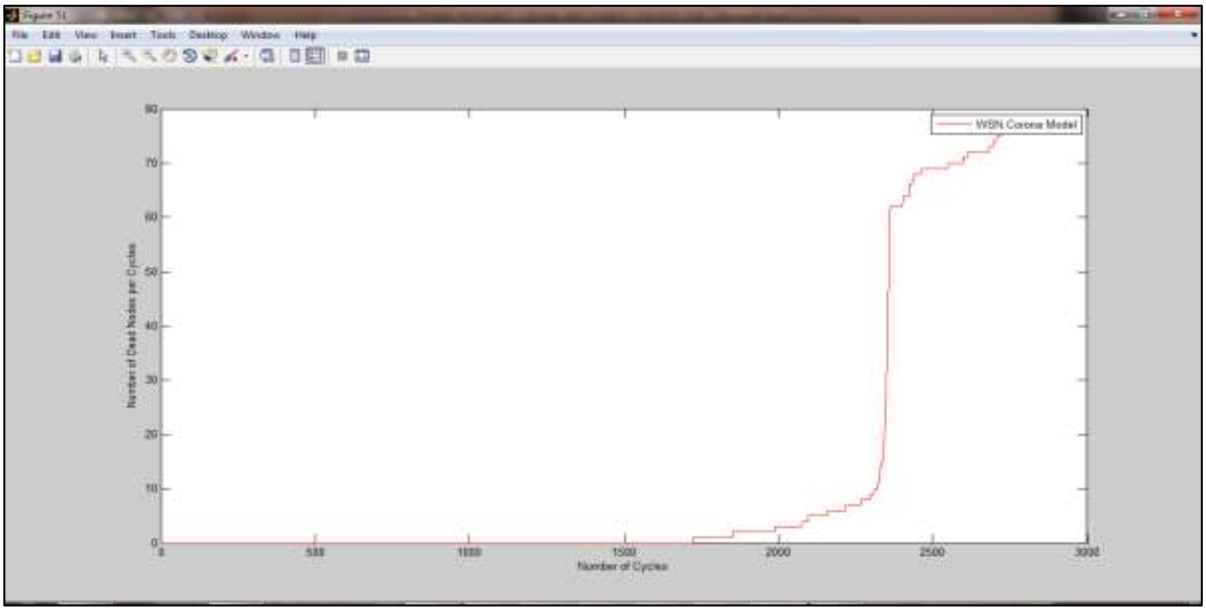

Fig. 2: Number of dead nodes per cycle in the network

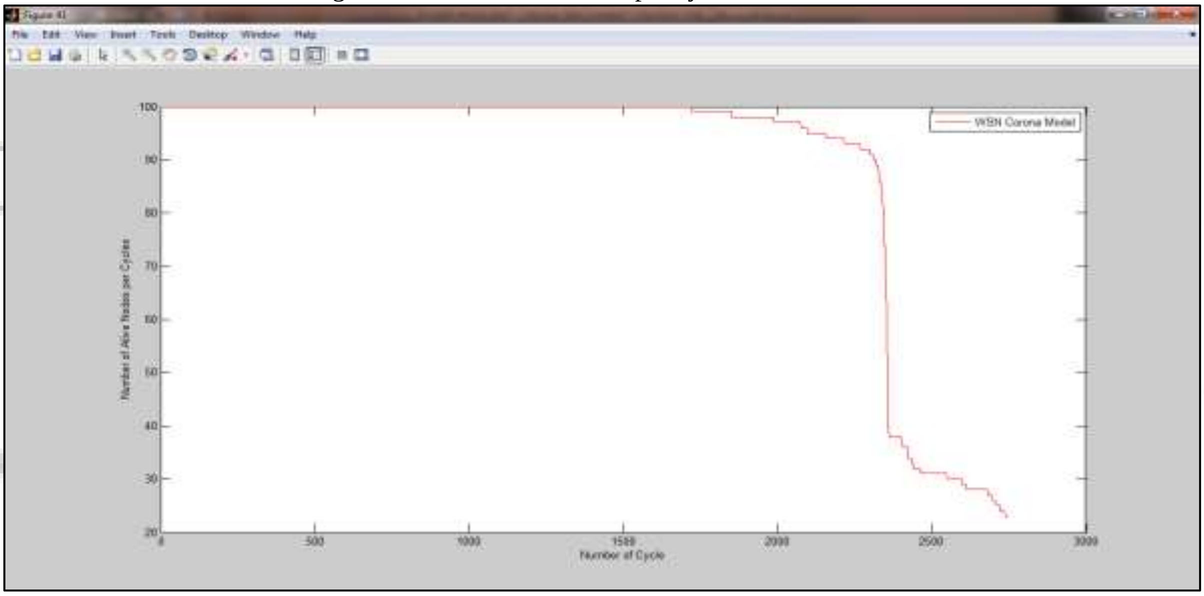

Fig. 3: Number of alive nodes per cycle in the network

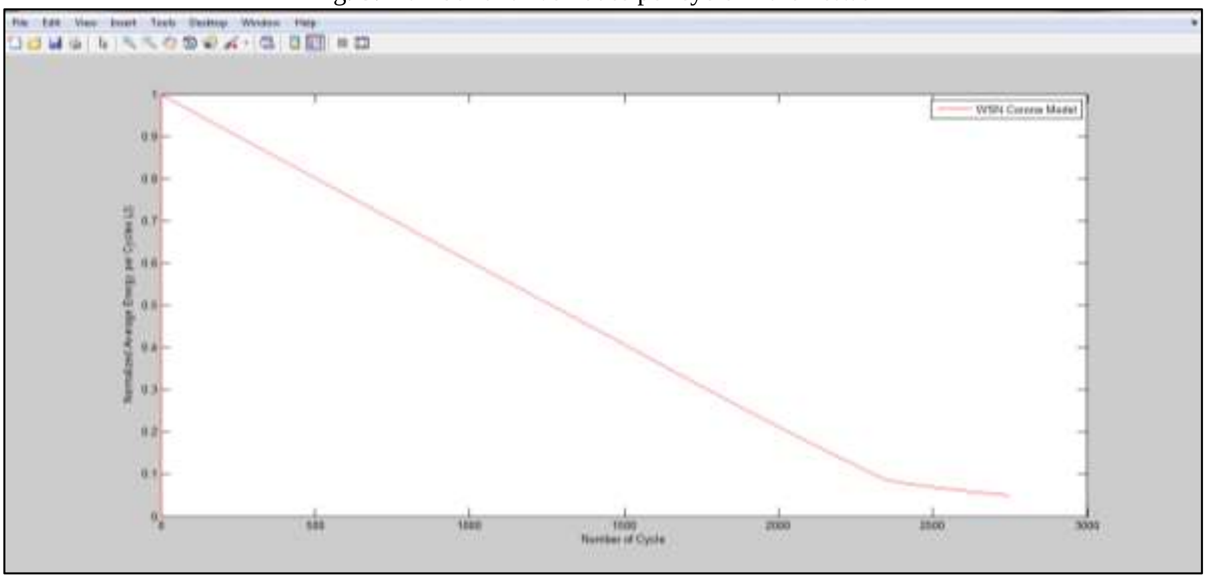

Fig. 4: Normalized Average Energy per cycles

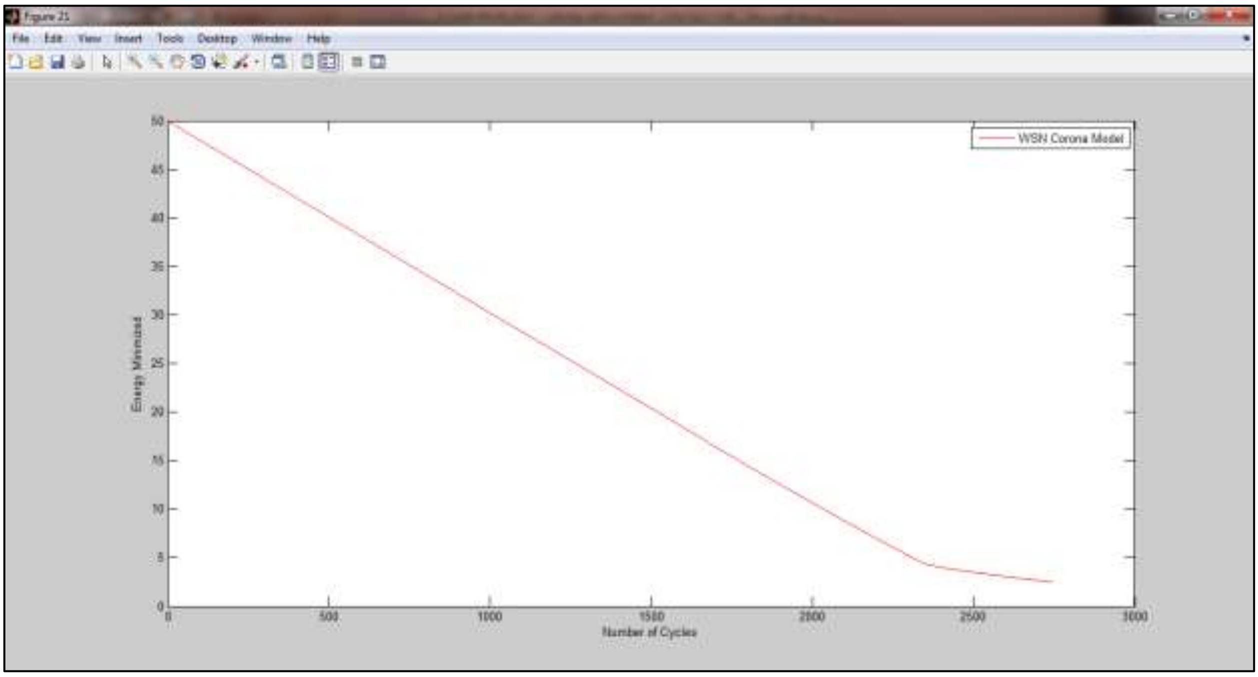

Fig. 5: Energy minimized in the network

This sensor dissemination system decreases the number of transmissions thus upsurges the lifespan of the network.

IX. CONCLUSION

The Corona centered energy stable non-uniform node distribution method for WSNs has been suggested. The measured network field in the proposed work has been partitioned into different of coronas with sink located at the middle of the deployment field. The area of each corona is same in size in the whole deployment field. The aim of the proposed strategy is to provide energy balancing in all coronas, eliminating energy hole and minimize coverage-hole problems of the network area. The performance of the proposed scheme is compared with the existing leach method. It has been analyzed that this method not only balances the energy through the network but also reduces and reduces coverage and energy-hole issues. The proposed method has been specially planned for the applications of restricted sensing range.

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