

# Improving the Nodule Lifespan and Security Using IDS in WSN

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**ABSTRACT:** Wireless Sensor Network (WSN) is a collection of sensor nodes to monitor the physical surroundings also in various application such as surveillance, tracking system, machine control, automation etc., WSN are deployed mostly in open and unprotected environment. Several security attacks are invoked in wireless sensor networks during the transmission of data. Because of its open nature wireless sensor networks are vulnerable to several kinds of attacks. So, the consideration of two parameters namely Probability Density Function (PDF) for improving the lifetime of the Wireless Sensor Nodes and securing the WSN from intruder makes Wireless Sensor Network more reliable. In this project, using the PDF to deploy the node for minimizing the waste of energy and then an Intrusion Detection System is applied on that environment to protect the Wireless Sensor Network (WSN) from malicious intruder. Thus the lifetime and security of WSN has been improved.

**KEYWORDS:** wireless sensor network, Probability density function, IDS

## I. INTRODUCTION

A Wireless Sensor Network (WSN) [1] is the collection of sensor nodes. Each one of these has an embedded processor and radio. These nodes operate together in the area being monitored and collect physical attributes of the surroundings, say temperature or humidity. Data gathered by these sensor nodes can be utilized various top level applications such as habitat monitoring, surveillance systems and also system monitoring such as various natural phenomena.

Each sensor node transmits data by itself have an own frequency for limited range with the required energy. Further a set of sensor nodes performs the communication within the network is said to be WSN

The main characteristics of WSN [1] include a Power consumption constraints for nodes using batteries, ability to survive with node failures, mobility of nodes, heterogeneity of nodes, scalability to large scale of deployment, ability to withstand harsh environmental conditions, Ease of use, and also Cross-layer design.

WSN [1] suffers many problems such as loss of packet in network layer, wastage of energy in transport layer, security, quality of service, deployment of nodes, medium access schemes, localization, synchronization, hardware and operating system for WSN and so on. In this project, node deployment and security focused as a major issue for improving the network lifetime. Node deployment is a process of arranging the sensor node at different layer in the WSN. Nodes are deployed both random and pre-determined manner. In a random manner, the node locations are not specified and in pre-determined the node locations are specified by any algorithms. The probability density function (PDF) [6] is developed for node deployment in WSN. PDF is represented by  $f(x)$ . It is used to find the approximate node density value.

Probability Density Function (PDF) [3] is a function that describes the relative likelihood for this random variable to take on a given value. The density function is a non-uniform one that is the value of PDF is higher for the nodes deployed around the sink whereas the value is lower as one moves away from the sink. However the nodes are deployed in network,

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it is difficult to identify whether the node is malicious or trusted. So, in order to provide security, an intrusion detection system (IDS) [4] is needed.

## II. RELATED WORK

Data Traffic and Distance Based Strategy: Azad et.al [6] have analyzed the network traffic and the energy usage distribution among networks to maximize the network lifespan with corona based network structure. They have analyzed and establish the ring thickness and hop size as a parameter and it is responsible for energy balancing. Based thickness and hop size has been determined. Through this scheme, increase the network lifespan along with optimal ring thickness and hop size. Consider the two other problems to redefining the optimization problem 1) concomitant hop size variation by sensors over lifetime along with optimal duty cycles, and 2) a distinct set of hop sizes of sensors in each ring. This existing problem brings the prolonged uniform energy usage in lower critical energy and additional improves the lifespan of the network. Simulation results show substantial improvements in terms of network lifespan and energy usage distribution over the existing policies.

Probability based strategies: A. Boukerche et.al [8] based on the probability of interest routing path selection with a target to balance energy consumption and enhance the network lifetime. They have considered the problem of achieving energy balanced data propagation in wireless sensor network. For maximizing the network lifetime, energy balance property is necessary. They have proposed a distributed, adaptive data propagation algorithm that exploits are limited, local density information for achieving energy-balanced propagation while at the same time keeping energy dissipation at low levels. They have proposed a density based probabilistic data propagation protocol on the way to balancing the energy consumption. Here the nodes are deployed in corona based network architecture. The density based protocol avoids the energy depletion and prolong the network lifetime.

STCDG: J. Cheng et.al [9], they have proposed a probability based data gathering mechanism that is spatio-temporal compression data gathering mechanism, where nodes send/forward sensory data to the sink because this paper is based on probability strategy. Compressive sensing(CS) based data gathering shows promise in meeting these requirements. CS-based communication solutions in the collection require that a transform that best sparsifies the sensor readings should be used in order to reduce the amount of data traffic in the network.

Furthermore, STCDG avoids the optimization problem involving empty columns by first removing the empty columns and only recovering the non-empty columns, using an optimization technique based on the temporal stability of the fill empty rows. The main advantage is low-rank and short-term stability features in WSNs to reduce the amount of traffic in WSNs and improve the recovery accuracy, ultimately leading to prolonged lifespan and lowered power consumption.

Deployment Based Strategies: X. Wu et.al [10] works on enhancement of network lifetime are based on judicious node deployment. The node are deployed in non-uniform distribution strategy used to ease the energy hole problem in WSN. Extra ordinary internal nodes of the network have the ability to be use. At the same time, it poses untapped energy in the corona region. They conclude that in a circular multi-hop sensor network (modelled as concentric coronas) with non-uniform node distribution, the constant data reporting and unbalanced energy depletion with all the nodes is unavoidable in the network.

On the other hand, if the number of nodes increases in geometric progression from the outer coronas to the inner ones except the outermost one, the balanced energy depletion is possible in the network.

## III NETWORK MODEL

From the analysis [11], a sensible network model for WSNs where the network area is covered by a set of concentric circles (corona based architecture) centered at the sink. The best position of the sink is the center of the circle. Though, in this architecture, energy consumption in annuli can be kept balanced but individual nodes in the annuli may remain imbalanced.

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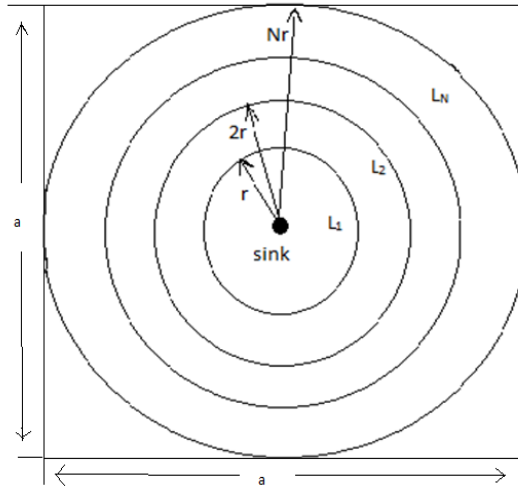


Fig: 2. Layered Network Areas

Consider a square shaped network area  $a \times a$  which is covered by a set of uniform-width corona or annuli [9], [12]. Each annulus is designated with width  $r$  as layer. The sink is considered to be located at the center of the network area and responsible for collecting data from the sensors nodes. Nodes are placed in different layers surrounding the sink. A layer is identified as  $L_i$  where  $i=1,2,\dots,N$ . here  $i=1$  represents the layer nearest to the sink and  $i=N$  represents the layer farthest from the sink where  $N=\lceil a/2r \rceil$ .

Here the nodes are stable and need to be deployed in each layer inside the network with certain node density. The node density is the relative amount of number of nodes in an area (layer) and the area (of the layer). We assume that there is no local co-ordination among the nodes (nodes may report same events to the sink) and also considering an idyllic MAC layer by way of no collision and retransmission so as to does not lose any statement. The basis for not considering an idyllic MAC layer is complexity such as collision occurs in each retransmission and scheduling etc.

### Sensing Representation

The sensing model describes a unit area to be covered, if the node in that specific area is within the sensing range is said to be active node. The nodes perform [13] at an angle  $360^\circ$ . The maximal circular area centered around a node  $v$  and it is defined as its sensing area  $S(v)$ . The radius of  $S(v)$  is called the  $v$ 's sensing range [12]  $R_s$ . Consider the relationship between  $r$  and  $R_s$  have to assure the condition  $r \leq 2R_s$  [5], [15] for covering the network area (fig.2). In case of 1-coverage, node density ( $\lambda$ ) =  $1/S(v)$ . Also, the coverage area  $C(X)$  of a set of nodes  $X$  is the union of the sensing areas covered by each node in  $X$  i.e.  $C(X) = \bigcup_{v \in X} S(v)$ .

### Communication Representation

The communication model describes a network as connected if any active node can communicate with any other active node. Consider that two nodes are directly exchange message if their Euclidean distance is not larger than the communication range  $R_c$ . Then the relationship between  $r$  and  $R_c$  should satisfy the condition  $r \leq R_c$  [5], [15] for ensuring connectivity in the network area (fig.2)

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## NETWORK LIFETIME ANALYSIS

From the analysis, they have analysis the two definitions namely network lifetime and node lifetime. **For node lifetime** [5], Consider the initial energy of each sensor node is  $\epsilon_0$  and the energy consumption rate of a node in layer- $i$  as  $ECR_i$ . The lifetime of a node in layer- $i$  is  $LT_i = \frac{\epsilon_0}{ECR_i}$ .

**For network lifetime** [5], the total number of nodes in layer- $i$  is  $T_i$ . The lifetime of a layer- $i$  in the network is  $\frac{\epsilon_0 \times T_i}{T_i \times ECR_i} = \frac{\epsilon_0}{ECR_i}$ .

Therefore, the network lifetime can be determined by the shortest lifetime of the layer and it is represented as  $\min \forall_i \left\{ \frac{\epsilon_0}{ECR_i} \right\}$ .

Further, consider that the area of a layer- $i$ (fig.1) is  $A_i = \pi(2i - 1) r^2$ , Where,  $r$  is the width of the layer. Consequently, the total number of nodes in layer- $i$  is given as  $T_i = \lambda_i \times A_i$  for  $i = 1, 2, \dots, N$ . Here  $\lambda_i$  represent the node density in layer- $i$ .

The transmission rate for data (own data) of a node in layer- $i$  is  $\frac{\rho}{\lambda_i}$ , where  $\rho$  is data generation rate in bits/sec to be transmitted towards the sink.

Now, the energy consumption rate of each node in layer- $i$  due to transmission ( $ECR_i^{Tx}$ ) [5] is given by (1) at the top of the next page.

Then the energy consumption rate of each node in layer- $i$  for receiving ( $ECR_i^{Rx}$ ) [5] data from the farther layer is given by,

$$ECR_i^{Rx} = \left[ \frac{\sum_{h=i+1}^N \lambda_h (2h-1) \rho}{\lambda_i (2i-1)} \right] e_r \dots 2$$

## IV. IMPLEMENTED SYSTEM

### PDF-BASED NODE EMPLOYMENT

The main aim is to deploy the node in the network layered area based on proposed PDF. For this deployment, establish  $i$  as a parameter which represent the layer count for both the proposed PDF and network layered area where  $i = 1, 2, \dots, N$ ; the parameter  $r'$  of the proposed PDF corresponds to the width  $r$  of the annuli/layer. Therefore, the relationship between  $r'$  and  $R_c$  is  $r' \leq R_c$ , whereas, between  $r'$  and  $R_s$  is  $r' \leq 2R_s$ . The PDF of deploying a sensor node at point  $f(x,y)$  located in layer- $i$  is given as follows:  $k(2i - 1)A_i/N^2i^4$  where  $i=1, 2, \dots, N$  and  $k$  is the proportionality constant.

The probability for the node deployed within a layer is  $k(2i - 1)A_i/N^2i^4$ , where  $A_i$  represent the area of layer- $i$  and  $k$ [5] is follows

$$k = N^2 \left[ \frac{\pi r^2 \sum_{i=1}^N (2i-1)^2}{i^4} \right]^{-1} \dots 3$$

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Here  $r$  is the width of the layer- $i$ . The area of layer- $i$  is given as

$$A_i = [\pi(2i - 1)r^2] .$$

By substitute the value of  $A_i$  , probability ( $p_i$ ) [5] of deploying nodes at the layer- $i$  is given as

$$p_i = k(2i - 1)^2\pi r^2 [N^2i^4]^{-1} \dots 4$$

The number of nodes in a layer- $i$  ( $T_i$ ) is equal to the probability ( $p_i$ ) of deployment of nodes at layer- $i$  multiplied by the total number of nodes ( $T_{total}$ ) i.e.  $T_i = p_i \times T_{total}$  .

Therefore, the node density of a layer- $i$  (for  $i= 1,2,\dots,N$ ) according to our proposed PDF [5] is given as

$$\lambda'_i = \frac{p_i}{A_i} \times T_{total} = \frac{p_i}{A_i} \times \sum_{j=1}^N \lambda'_j \times A_j$$

$$\lambda'_j = \frac{k(2i - 1)\pi r^2}{N^2i^4} \sum_{j=1}^N (2j - 1)\lambda'_j$$

### CALCULATING NETWORK LIFETIME

From the analysis, the network lifetime is calculated. It has been show that the same can be achieved by regulating transmission range of nodes in each layer. Indeed, network lifetime extension as transmission range regulation based optimization problem. Consider that the energy essential to transmit one bit of data in the farthest layer is  $e'_t = e_{elec} + e_{amp} R_{c_0}^2$  and also obtain energy balancing the average energy consumption rate must be same of each layer. i.e.,  $ECR_i = ECR'_N$ , where  $ECR_i$  is energy consumption rate of a node in layer- $i$  and  $ECR'_N$  [5] is energy consumption rate of the node of layer- $N$ . Now use equation (1),(2) and  $ECR_i = \begin{cases} ECR_i^{Tx} + ECR_i^{Rx} \\ ECR_N^{Tx} \end{cases}$ , which tends[5],

$$\frac{\rho}{\lambda_i} e_t + \frac{\sum_{h=i+1}^N \lambda_h (2h - 1)\rho}{\lambda_i (2i - 1)} (e_t + e_r) = \frac{\rho}{\lambda_N} e'_t$$

Now replacing the value of  $e'_t$  and using

$$m_i = \left\{ \begin{array}{l} \frac{\rho}{\lambda_i} + \frac{\sum_{h=i+1}^N \lambda_h (2h - 1)\rho}{\lambda_i (2i - 1)} \\ \frac{\rho}{\lambda_N} \end{array} \right. , \text{ which results [6],}$$

$$m_i e_t + \frac{\sum_{h=i+1}^N \lambda_h (2h - 1)\rho}{\lambda_i (2i - 1)} = m_N (e_{elec} + e_{amp} R_{c_0}^2)$$

Rearranging the above equation [5], this results (6) and (7) at the next page.

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Where,  $T'_i$  represent the network lifetime in layer.  $R_{c_0}$ (8) and  $R_{c_i}$ (9) represent the network lifetime of layer and farthest layer.

$$ECR_i^T = \begin{cases} \left[ \frac{\rho}{\lambda_i} + \frac{\sum_{h=i+1}^N \lambda_h (2h-1)\rho}{\lambda_i (2i-1)} \right] e_t & \text{for } i = 1, 2, \dots, (N-1) \\ \frac{\rho}{\lambda_N} e_t & \text{for } i = N \end{cases} \dots 1$$

$$R_{c_0} = \left[ \frac{1}{M_N e_{amp}} \left( m_i e_t + \frac{\sum_{h=i+1}^N \lambda_h (2h-1)\rho}{\lambda_i (2i-1)} e_r - m_N e_{elec} \right) \right]^{\frac{1}{2}} \dots 6$$

$$R_{c_i} = \left[ \frac{1}{M_i e_{amp}} \left( \frac{\rho}{\lambda_N} e'_t - \frac{\sum_{h=i+1}^N \lambda_h (2h-1)\rho}{\lambda_i (2i-1)} e_r - m_i e_{elec} \right) \right]^{\frac{1}{2}} \dots 7$$

$$R_{c_0} = \left[ \frac{1}{M_N e_{amp}} \left( m_i e_t + \frac{\sum_{h=i+1}^N \lambda_h (2h-1)\rho}{\lambda_i (2i-1)} e_r - m_N e_{elec} \right) \right]^{\frac{1}{2}}, \forall T'_N \dots 8$$

$$R_{c_i} = \left[ \frac{1}{M_i e_{amp}} \left( \frac{\rho}{\lambda_N} e'_t - \frac{\sum_{h=i+1}^N \lambda_h (2h-1)\rho}{\lambda_i (2i-1)} e_r - m_i e_{elec} \right) \right]^{\frac{1}{2}}, \forall T'_N, i < N \dots 9$$

$$\begin{aligned} (N \times r) &\geq R_{c_0} > R_{c_i} > 0 \quad \forall T'_i, 1 \leq i \leq N \\ (ECR'_i \times LT''_i) - \epsilon_0 &\leq 0 \quad \forall i \in \{1, 2, \dots, N\} \\ (ECR'_i, LT''_i) &\geq 0 \quad \forall i \in \{1, 2, \dots, N\} \end{aligned}$$

### V. PERFORMANCE EVALUATION

#### A. Simulation Environment

The simulation is performed using network simulator 2.34. The performance of this scheme the four performance metrics have been adopted they are network lifetime, packet drop ratio, throughput and packet drop.

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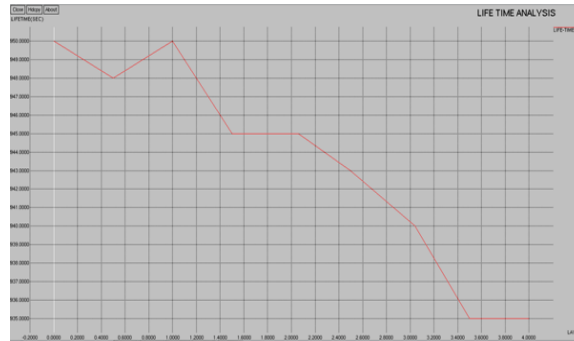


Fig 3. Network lifetime analysis

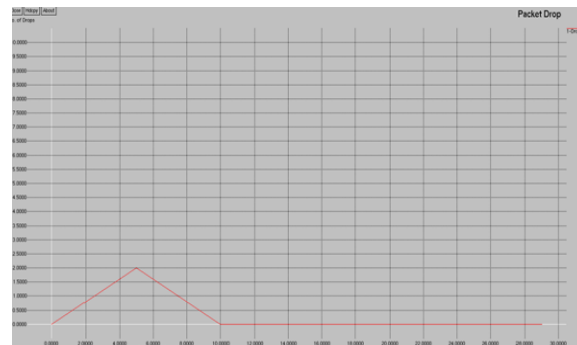


Fig 4. Packet drop ratio

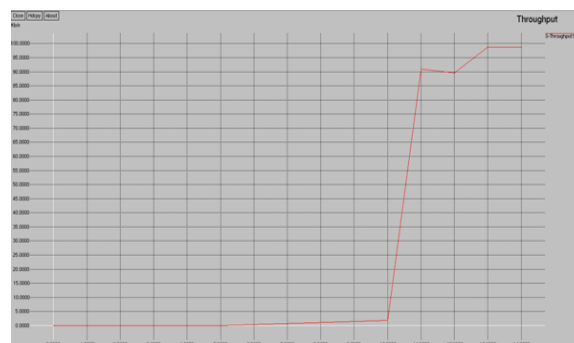


Fig 5. Throughput analysis

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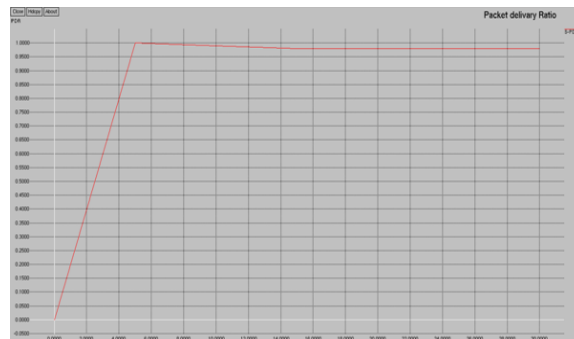


Fig 6. Packet delivery ratio

## VI CONCLUSION AND FUTURE WORK

In this project work, node employment scheme for multi-hop WSNs using a PDF have been proposed. To attain energy balancing and maximizing the network lifetime is the main aim of this scheme at the same time it maintains coverage and connectivity. The network lifetime can be analysed and acknowledged by means of node density as a parameter. Then, the theoretical formulation of node density and network lifetime are calculated. Node employment algorithm can be developed based on PDF. As a future work, the real nature and the function of each and every node can be validated by using intrusion detection system (IDS). By use of the detection scheme, network lifetime has to be improved and also provides the security to the WSN.

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