

Energy Efficient Model for Maximizing the Network Coverage Time in Non-Deterministic WSN Model



Savitha S, S.C. Lingareddy, Sanjay Chitnis

Abstract-WSN are the group nodes and these nodes are grouped into several clusters, each cluster has its own CH (Cluster Head). Moreover, each cluster Head collects the data and sends either through the corresponding CH or through the CH. Moreover, the clustering plays one of the eminent role in WSN, since Clustering reduces the energy consumption in the cluster Head and improvises the lifetime and scalability of WSN. However, this maximizes the burden on the CH and certainly, it causes the coverage loss. Hence, in this paper we design a model named as EE-NCT (Energy Efficient model for maximizing the network coverage time) which helps in increasing the Network Coverage time for the non-deterministic model, i.e. Sensor nodes location are not known. Non –deterministic model makes hard to maximize, as the node placement is not known. Moreover, this is achieved through monitoring the sensor node location and applying the routing based clustering scheme. Our model is evaluated by considering the various constraint such as first sensor node death, 75% of node death and loss of connectivity by considering the parameter as energy consumption and average number of failed nodes.

Keywords- Energy Efficient, Non-deterministic model, WSN, Network Coverage Time.

I. INTRODUCTION

Wireless sensor networks (WSNs) are composed of a large number of communication nodes with limited sensing, processing and computational capabilities and one or more data sinks located either at the center or out of the sensing field [1, 2]. The sensor nodes are deployed in a desired area to monitor environmental parameters or to detect some specific events (e.g., forest fire [3], battlefield surveillance [4], target moving [5] and other application [6-8] where the data are sensed and then sent to the sink or sinks through single-hop or multi-hop wireless routing [9]. Distinguished from traditional wireless networks, the sensor nodes of WSNs are limited in power, computational capacity and memory. In harsh and inaccessible deployment circumstances, sensors are necessarily powered by energy-constrained, often non-rechargeable batteries. With time elapsing, some nodes will run out of battery and let the WSN in a disconnected state.

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This makes the energy consumption [11] become a critical factor in the design of a WSN and calls for energy-efficient communication protocols that maximize the lifetime of the network [11].

Wireless sensor network is the composition of huge finite number of sensor nodes located at the sensor field, it has the restricted computational capabilities processing speed and sensing capabilities. Moreover these sensor nodes has been deployed for monitoring the several phenomena such as target moving, surveillance etc. and these data are sent to the sink through the routing, the routing can be either multi-hopping or single routing . Moreover, sensors in WSN are organized into various cluster for flexible transmission of data, these clusters have cluster head. Hence, instead of directly transferring the data to sink it is transmitted via cluster Head. This in terms helps in reducing the energy consumption [12]. However this phenomena puts more load on the Cluster Head, this causes the more energy consumption by Cluster head and need for the more power supply. Moreover, this results in non-complete coverage of sensing region.

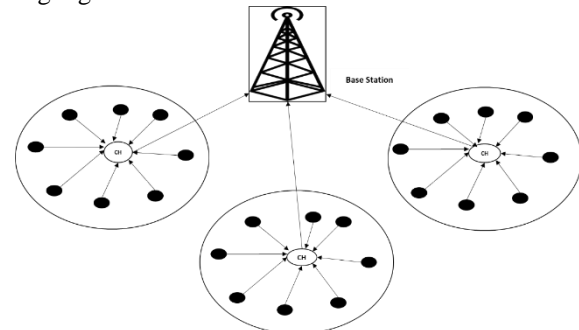


Figure 1 clustering in WSN

The above figure shows the clustering approach which consist of Cluster Head, sensor nodes, clusters and base stations. In the literature review of balancing the load and energy at first the LEACH protocol [13] is proposed which uses the distributed clustering method, here the CH were selected randomly as well as probabilistically in the distributed, this guarantees the whole nodes is chosen at least once in the given N/k rounds. K denotes the number of cluster head and N denotes the number of nodes in the given network. However, energy factor was not considered while selecting the Cluster Head. Moreover, other variants of LEACH such as [14, 15, and 16] were proposed to improvise the performance of LEACH. [17] Proposed the Dynamic CH selection, this method tries to discard the overlapping network coverage.

In [18] a technique named as DECH is presented, this improvises the previous LEACH technique, TEEN [19], DEEC [20] and [21] was proposed for energy consumption and improvising the network lifetime. Here, at first DECH chooses CHS by helping the conventional protocols. The methods selects the CH in random and few CHs are placed closer to each other this reduces the network performance. Moreover, DECH observes and replaces those nodes with the new CHs. However the main issue it faces is re-selection process, this increases the overhead. Moreover, EEPCT [22] integrates the distributed and centralized algorithm and selects the Cluster Head based on the closeness of nodes; this modifies the selection of CH threshold to improvise the performance.

MOTIVATION AND CONTRIBUTION OF THIS RESEARCH WORK

Sensor node in WSN are organized into various clusters, these clusters have their own CH, so instead of direct communicating to the base station, these nodes submits their data to the CH then CH forwards the data to the Base station either directly or through the intermediate Cluster Heads. Moreover the reduces the power load on the particular node. Clustering provides the various advantage apart from reduction in energy consumption such as security, scalability and network management. However clustering causes the more load to the Cluster Head, which causes their battery to drain in first place, this directly affects the more energy consumption by CH and once the CH is dead there is no communication between the node and the base station. Hence, it is important to maximize the Network Coverage time. Our scheme considers the non-deterministic model of WSN, as it is more complicated since the node placement are unknown. It involves the hop count based where the location as well as the cluster of size is taken into consideration. The contribution of the research work are listed below

- Increase the Network Coverage time through the optimization technique.
- Developing the energy efficient model for Non-deterministic model
- More robust considering the non-deterministic model.
- EE-NCT reduces the energy consumption and failed nodes
- Extensive simulation has been performed to evaluate EE-NCT

Our research work is organized in various section, first section discuss about the background of WSN and addresses several problems related to the WSN such as limited functionality of sensor nodes. Moreover, in the same section, method such as clustering is discussed and later section discusses the few existing methodology. Second section focus on the motivation and contribution of this research article, third section focuses on the proposed methodology. Performance evaluation is done in the fourth section, followed by that our research work is concluded.

II. PROPOSED MODEL

NETWORK MODEL

Let us consider a model of particular region ψ of given angle \emptyset , sink is located, moreover the sink is located the vertex of the graph. Here we have considered a cone like structural field. Sensors are distributed in a uniform manner across the given region ψ with density ρ . Moreover, only the node with distance r_o can communicate in a direct manner with the sink and remaining sensors communicate through the CH; this happens by designing the clusters. Cluster can be designed based on the several parameter such as distance based. Here it is assumed that each cluster head is placed at the center of the cluster.

Problem Statement

Let there be E_i which indicates the Energy consumption for the i th structure, then the following model is considered as the energy, where the receive circuit is eng_{rx} which depicts the energy consumed in the receiver mode and the eng_{tx} indicates the energy consumed in transmission mode. γ_{ri} is the inter-cluster traffic, γ_{oi} is intra-cluster traffic. E_{Ti} is the power transmitted.

$$E_i = eng_{rcv}(\gamma_{oi} + \gamma_{ri}) + eng_{tx}(\gamma_{oi} + \gamma_{ri}) + E_{Ti}(\gamma_{oi} + \gamma_{ri}, RS) \quad (1)$$

EE-NCT model

$$Minimize \max \{E_1, E_2, E_3, \dots, E_k\} \quad (2)$$

Equation (14) leads to the optimization problem and solved using

Hop-based routing

In this section we solve the clustering problem through Hop-by-Hop routing, in this routing scheme, here cluster head in the r th ring transmits the particular data to the adjacent Cluster head in the given $(r-1)$ ring. Let us consider any variable $dist_i$ which is the distance between the two Cluster Head, hence the Power transmission between these two can be written through the below equation.

$$E_{Tr} = TE_r(\gamma_{ICr} + \gamma_{RCr}) \quad (3)$$

TE_r is the energy transmitted per bit, hence the power consumption of cluster Head in the given ring r is given through the below equation.

$$E_r = (eng_{rc} + eng_{tre} + TE_r)(\gamma_{ICr} + \gamma_{RCr}) \quad (4)$$

Moreover, the energy received is given as

$$eng_{RCr} = TE_r M(e_0) \left(\frac{r}{e_0}\right)^{-t} \text{ and} \quad (5)$$

Moreover the reliability requirement is expressed through the below equation

$$\eta_i = eng \frac{\varepsilon dist_i^n}{eng_{ti} L(e_0)} e_0^n \quad (6)$$

Here we have considered minimum Hop routing; the maximum number of link of the path from source to destination is K. Moreover, to guarantee the constraint δ_p , the minimum link reliability should be as given in equation.

$$\eta_{rel} = \eta_E^{p-1} \quad (7)$$

Moreover equating (18) and (19), we get the reliability requirement, which is given by:

$$eng_{ti} = \frac{-P \epsilon dist_i^t}{L(e_u) e_u^n \log \eta_E} \quad (8)$$

Let's calculate the approximation which gives the upper bound on the given time and it is obtained through replacing x_i in equation (20) along with the lower bound and it is given as

$$dist_{rmin} = \begin{cases} \frac{\kappa_1 + \kappa_0}{2}, & \text{for } r = 1 \\ \frac{\kappa_i - \kappa_{i-2}}{2}, & \text{for } r = 2, \dots, P. \end{cases} \quad (9)$$

Moreover the lb is retrieved through adding the cluster radius in the i th circle and the radius of nearest cluster in $(i-1)$ th ring. Let us consider the γ_{totali} , which denotes the bit rate of aggregate traffic which is derived from the given clusters in the rings i through K.

$$\gamma_{totali} = \pi(K^2 - \kappa_{r-1}^2) \eta \gamma \frac{\phi}{2\pi}, \quad i = 1, \dots, P \quad (10)$$

Since the relaying is done through hop-to-hop, the traffic load carried is same as the traffic volume originated from the clusters in the ring i to K. the number of CH is computed through the below equation.

$$T_r \approx \frac{2\pi\kappa_r\phi}{(2\pi)\kappa_r - \kappa_{r-1}} \quad (11)$$

Moreover, the average traffic load on cluster Head in the given ring I is given by

$$\gamma_{ICr} + \gamma_{RCr} = \frac{\gamma_{totali}}{T_i} \quad (12)$$

The above equation (24), (20) and (21) in (16), since $\frac{\gamma_{totali}}{T_i} \approx \frac{(R^2 - r_{i-1}^2)(r_i - r_{i-1})}{2r_i} \zeta \gamma$.

Energy consumption is given as:

$$E_1 = \left[eng_{ICr} + eng_{RCr} + \frac{P\zeta}{-L(d_o)d_o^n \log \delta_p} \left(\frac{r_1 + r_0}{2} \right)^t \right] \times \frac{(K^2 - K_0^2)(k_1 - k_0)}{2k_1} \zeta \gamma, \text{ for } r = 2, \dots, P \quad (13)$$

$$E_r = \left[eng_{ICr} + e_{RCr} + \frac{\zeta_T}{-M(e_o)e_o^n \ln(\eta_E)} \left(\frac{r_i + r_{i-2}}{2} \right)^n \right] \times \frac{(K^2 - k_{r-1}^2)(k_r - k_{r-1})}{2k_1} \zeta \gamma, \text{ for } i = 2, \dots, P \quad (14)$$

Optimization of this problem is given as in the below equation.

$$\begin{cases} \text{minimize}_{\{k_1, \dots, k_p\}} \{ \max\{E_1, \dots, E_p\} \} \\ \text{such that} \\ k_0 < k_1 < \dots < k_p = K \end{cases} \quad (15)$$

Where E_r , $r=1 \dots P$, are given by (25) and (26), later the auxiliary variable is introduced in the above equation which forms the below equation.

$$\begin{cases} \text{minimize}_{\{k, var\}}^{var} \\ \text{Such that} \\ var^{-1} E_r \leq 1, \quad i = 1, \dots, P \\ k_{r-1} k_r^{-1} < 1, \quad i = 1, \dots, P \\ k_p = Z \end{cases} \quad (16)$$

Objective function is power product and above equation presents the optimization problem and can be optimized through the below equation.

III. PERFORMANCE EVALUATION

In this section, we evaluate the proposed energy efficient and load balanced model we have performed the extensive simulation and compare with the existing methodology. Simulation was perform on the visual studio 2017 version on the windows platform by using C sharp as a programming language. Moreover, the evaluation was performed on the single system which has the configuration of 1 TB SATA hard disk packed with 2 GB NVidia graphics and 8 GB RAM.

For the evaluation process we have considered the two main parameter i.e. energy consumption, number of failed Nodes and four different number of nodes were considered as 450, 550, 650 and 750. Moreover, for the further evaluation we have considered three different constraint described later in the same section as 75% node death, first sensor node death and network connectivity issue. These three were the primary constraint where the existing methodology discuss in the introduction section fails.

Energy Consumption

Energy consumption is one of the key parameter, which is considered, as the most of the WSN are battery based and it has the limited energy supply, hence energy consumption should be as less as possible. Meanwhile it is also obvious that we consider the number of failed nodes as one of the parameter.

First sensor node death

We have considered this as one of the constraint while evaluating the proposed methodology, when a model is designed several constraint has to be considered it is one of the main constraint. A model is said to be efficient if it passes through the fault-tolerant property. Hence, to test the fault tolerance property we have considered this as one of the parameter i.e. when model is designed, how model performs if the first node itself is dead. In graph, i.e. Fig 2 we observe that energy consumed by existing methodology is comparatively more than the proposed one. Similarly fig 3 presents the comparison analysis of number failed nodes, the less number of failed nodes indicates the more efficient.

Moreover, we observe that in case of first sensor node death our model consumes nearly 13%, 10%, 29% and 12 % less energy than the existing model.

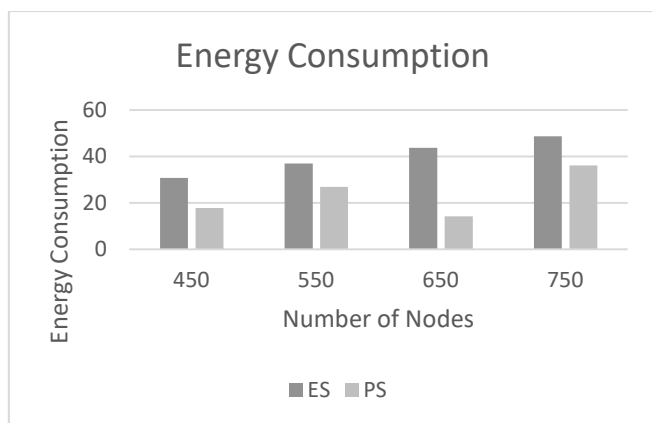


Figure 2: comparison of existing and proposed model

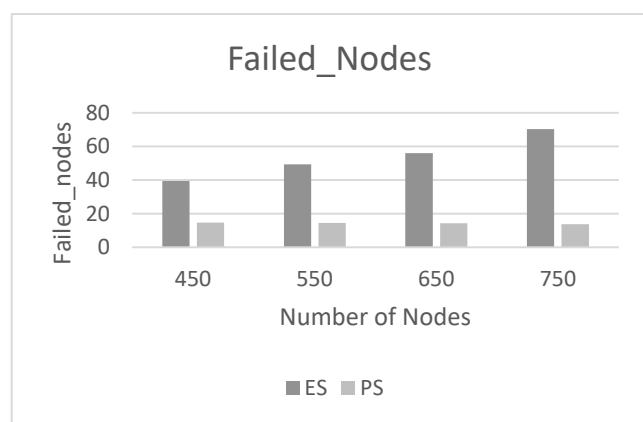


Figure 3: comparison of existing and proposed model

75 % node death

Another constraint we have consider is the performance of the model when 75 % node is dead, below figure 4 and figure 5 shows the comparative analysis of existing and proposed model. The energy consumption for 450, 550, 650, and 750 are nearly 2%, 10%, 18% and 21% less when compared to the proposed model.

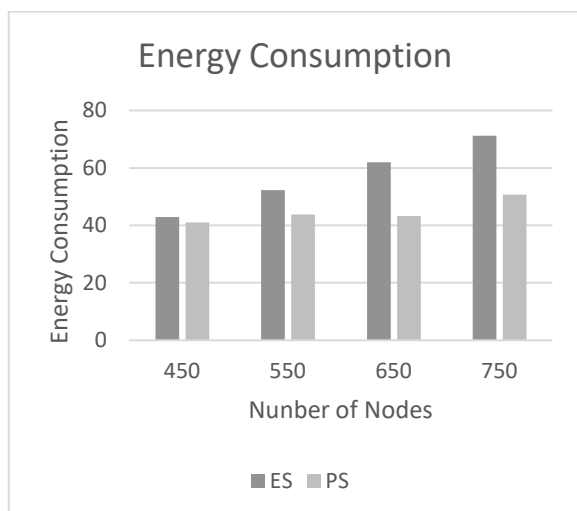


Figure 4: comparison of existing and proposed model

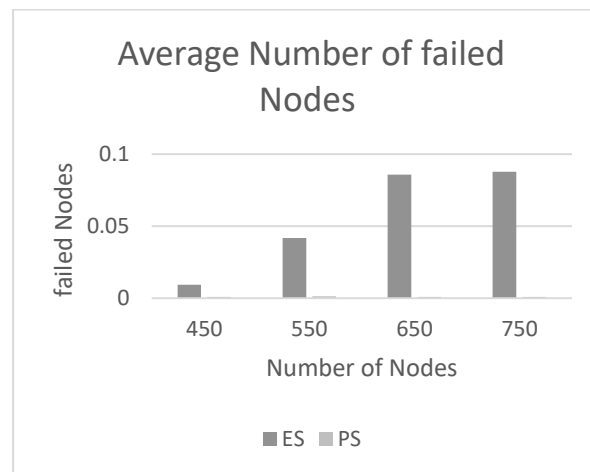


Figure 4: Comparison of existing and proposed model

Loss of Network connectivity

Network connectivity is one of the eminent parameter; loss of network connectivity can take place due to several reason such as physical entity. Figure 6 and Figure 7 represents the energy consumption and number of failed nodes respectively, from graph we observe that proposed methodology is more efficient than the existing one. Moreover our model consumes 2%, 2%, 4% and 3% less energy than the existing model while considering the number of nodes as 450, 550, 650 and 750 nodes.

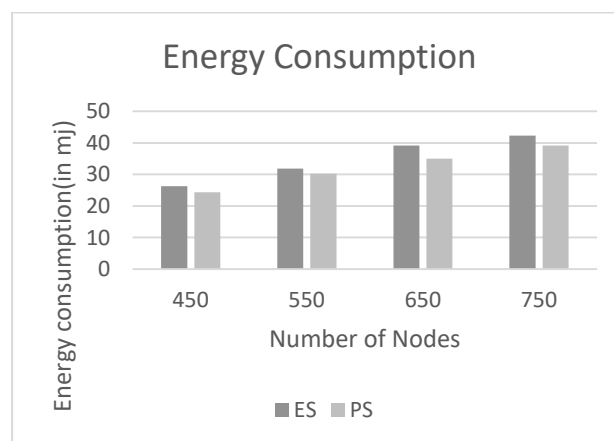


Figure 5 energy consumption comparison between existing model and proposed model

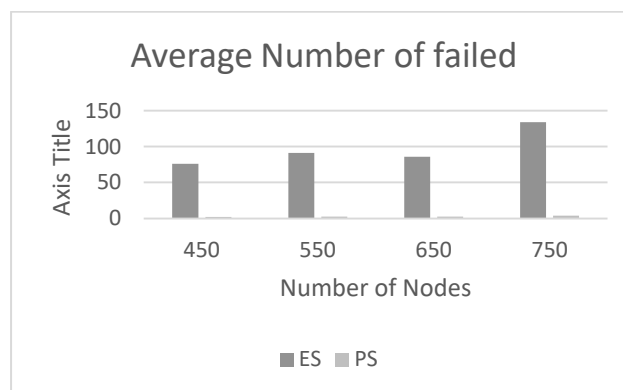


Figure 6 comparison of average number of failed

IV. CONCLUSION

In this paper, we have proposed a model named as EE-NCT, which maximizes the Network coverage time in Non-deterministic model. To achieve that we have routing based clustering, were used, Our model is evaluated through extensive simulation using the several number of nodes such as 450, 550, 650 and 750 based on the two parameters i.e. energy consumption and average number of failed nodes by considering the various constraint such as death of first sensor node, average number of failed nodes and loss of connectivity. In the comparison analysis, we observe that our model consumes the less energy when compared to the existing model in all this constraint, similarly our model has less number of failed nodes. Moreover in future work we would be considering more constraint and observe how the model performs and parameter selected is limited hence in the next work we would be considering several number of parameter.

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