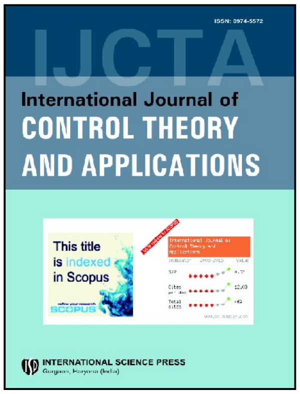


International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 10 • Number 10 • 2017

Optimized Routing and Cluster Head Selection Protocol for Wireless Sensor Networks

V. Manohar Reddy[1] and K. Vijayan[2]

[1] *M. Tech, Department of Telecommunication, SRM University, E-mail: manoharluminous888@gmail.com*
[2]*Assistant professor (Senior grade), Department of Telecommunication, SRM university, E-mail: vijayankvijayan@gmail.com*

Abstract: In wireless sensor networks, energy is the main constraint for nodes which cannot be replaced after deployed. Hierarchical routing is employed to increase the network life time. To resolve illegal cluster head selection problem which will cause overlapping coverage we are selecting dynamic cluster head selection method. A optimized routing and cluster head selection method for wireless sensor networks (ORCHS) is proposed in this paper by analyzing the sensor network energy consumption based on the redundant nodes and energy heterogeneity. The experiment analysis is carried on four aspects including coverage, life cycle, active nodes and the average residual energy. The method proposed in this paper overcomes the disproportion of the energy consumption, improves the information redundancy in the process of transmission, reduced energy consumption and extend the lifetime of the network. Result shows that ORCHS protocol method balances the energy between the nodes in two phases. Comparing with the existing algorithm this method has 56% longer network lifetime then LEACH and 26% lifetime longer the DEEC, also survival time of the network is higher than other protocol.

Keywords: Optimized Routing, Cluster Head Selection, Voronoi, Wireless Sensor Networks, Hierarchical, Residual Energy, Dynamic, Sensor Nodes, Redundant Nodes, Coverage, Heterogeneity.

1. INTRODUCTION

Wireless sensor network are widely deployed for agricultural, military, civil and other applications. The major function of wireless sensor network is monitoring the environment or a particular area. Group of Sensor nodes are deployed in application area and provided energy source for working [2]. By collecting the data from the environment and send it to the base station through the gateway. Generally, sensors nodes are having limited energy, low storage capacity and weak computing ability. Due to the unsafe working environment resources may not be replaceable or rechargeable. Hence one of the major challenges in the wireless sensor network is to increase the lifetime of the sensor nodes. Many improvements have been done for optimizing these problems.

Each Sensor node is differing in their characteristics like energy level, separation distance etc based on the application area. We can say that they are application dependent [2]. Energy consumption can be effectively reduced when the sensor network is divided into number of clusters and in each cluster one node is selected as a cluster head. This cluster head will receive the data from the neighboring nodes and send it to the base station, instead of each node sending directly to the base station [6]. This will increase the life time of the network.

2. RELATED WORK

The routing protocol design is challenging for wireless sensor networks as it is having several network constraints. Wireless sensor networks having several network resource limitation such as energy, bandwidth, storage and central processing unit. The design challenges in WSN involve limited energy capacity, sensor location, limited hardware resource, massive and random node deployment, network characteristics and unreliable environment, data aggregation, diverse sensing application requirements and scalability.

The existing algorithms are to maximize the coverage area, reduce the overlapping and gap and to deploy the nodes uniformly. But these are not having longer network life time. In this section, we are focusing on cluster head selection and optimize routing between the cluster heads and base station. Here monitoring area is divided into cluster using Voronoi diagram [17]. The nodes that do not affect the performance of the network coverage even after the death of nodes are selected as primary cluster head. The sensing ability of this cluster heads is disabling to reduce the energy consumption for sensing. When primary cluster heads are died, secondary cluster head are selected using survival time estimation algorithm based on the average energy of the network and residual energy. This method improves the information dismissal and imbalanced energy consumption. Some of the related works are mentioned below about the weakness of existing methods.

In general many routing protocols were developed for wireless sensor networks. All the protocol for wireless sensor networks are divided into seven categories. They are location based protocol, data centric protocols, hierarchical protocols, mobility based protocols, multi-path based protocols, heterogeneity based protocol and QOS based protocols. In this paper we are going to see about hierarchical protocols.

2.1. LEACH (Low energy adoptive clustering hierarchy) is the first cluster based protocol for wireless sensor network [1]. In LEACH, network is divided into small number of clusters which are formed in a self organize manner. Selected node in each cluster gathers the sensor data from the neighboring node and sends that to base station. In LEACH protocol cluster head are selected randomly [1].

Drawbacks

- There is no communication between the clusters in the networks because the cluster heads directly commented with base station. This consumes more power for the transmission. Hence it is not suitable for large scale networks.
- Cluster heads are not uniformly distributed in the network hence cluster heads may be located at the corner of the cluster.
- Cluster heads are selected randomly, so it won't consider the amount of energy consumption. Hence same node will be selected as a cluster head for much iteration.
- Due to the change in cluster head for each iteration additional overheads will be occurred.

2.2. DEEC (Distributed Energy Efficient Clustering)Protocol uses initial energy and residual energy of all nodes to select the cluster heads. This protocol approximate the network lifetime for reference. This protocol is for heterogeneous wireless sensor network. It can be implemented on multiple heterogeneous networks [17].

Drawbacks

- In DEEC advanced nodes are castigate, particularly when the residual energy is reduced and become in the range of normal nodes.
- In this situation the advanced nodes die rapidly.

2.3. HEED (Hybrid Energy Efficient Distributed Clustering) Protocol is the extension of basic LEACH Protocol. It is designed to select cluster head in the network based on the amount of energy distributed in relation to the neighboring nodes. It prolongs the network life time by distributing energy consumption terminates the clustering process with in the constant number of iterations. It minimizes the overheads.

Drawbacks

- The periodic cluster head rotation needs excess energy to reconstruct clusters.
- The random selection of cluster heads may cause higher communication over heads for :
  - The ordinary member nodes in communicating with their corresponding cluster heads.
  - Cluster heads in establishing the communic-ation between them.
  - Between a cluster head and a base station.

2.4. TEEN(Threshold sensitive Energy Efficient sensor Network)protocol uses a data centric method with hierarchical approach. Its stability for time critical with sensing application is the important feature of TEEN. Data transmission is often controlled commendably supported by the threshold. Cluster head broadcasts threshold values which are minimum possible value to trigger a sensor node.

Drawbacks

- Sensing applications which need periodic reports, TEEN is not appropriate as the user won't get any data if the threshold is not reached.
- As the information transmission is accomplished only at cluster heads the data will be vanished if the cluster heads are not in the communication range.

3. OPTIMIZED SELECTION OF CLUSTER HEADS

Initially voronoi diagram is used to cover the maximum coverage by dividing the monitoring area into small cluster. Based on the coverage area cluster heads are selected which are having most redundant nodes. Hence the smaller cluster will have highest time by changing the cluster heads without changing the complete coverage area.

The selection process of optimized primary cluster heads is shown in the figure 1.Selection process will be as below:

- Network initialization .Location of all the sensor nodes in the examining area and residual energy will be recognized by the base station.
- Examining area is divided into small clusters by voronoi diagram and the sensing probabilistic model is proposed by using attenuation probabilistic algorithm redundant nodes are selected and is nodes are considered as the primary cluster head nodes.
- After death of primary cluster head nodes, another redundant node is selected as a cluster head.
- To estimate the network average residual energy survival time estimation algorithm is used. Secondary cluster head nodes are selected based on the ration of the residual energy and the average energy of the network nodes.
- The redundant nodes impact and the residual energy of the network is larger in the process which makes the redundant nodes and the average residual energy is targeted in this paper.

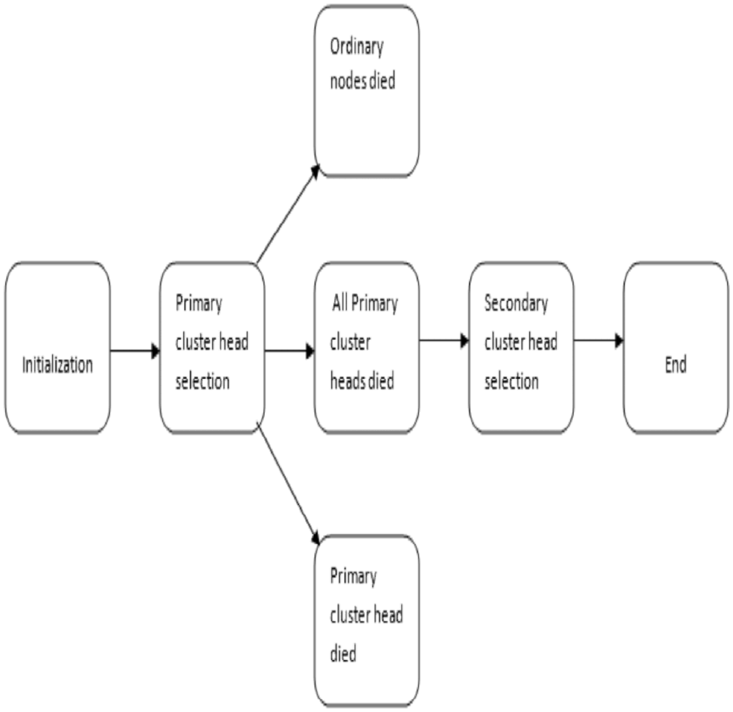


Figure 1: Optimized cluster head selection process

3.1. Primary Cluster Head Selection Based on Sensing Probability

Distributions of sensor nodes randomly in the monitoring area may lead to the overlapping hence make part of nodes active and other nodes asleep. Then the node coverage model is proposed based on voronoi diagram. It mainly includes selection of active nodes, mesh generation of voronoi diagram. Consider that the monitoring area is two dimensional rectangular planer regions and base station is at the center. Let R_s represent the sensing radius of sensor nodes and R_c represents the communication radius, which gratify $R_s \geq R_c$. A node centered circular area which has sensor node S_i and R_s represent the radius was defined as the sensing range of the sensing node. Every point m in the monitoring area is denoted by its coordinate $m(x_j, y_j)$ and S_i coordinates is $S_i(x_i, y_j)$. The distance between the node S_i and m is

$$d(s_{i,} m) = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{1}$$

The sensitivity probability model of S_i to m is

$$P(s_i, m) = \begin{cases} 1 & d(s_i, m) < R_s + \mu \\ e^{-ad} & R - u \leq d(s_i, m) < R + \mu \\ 0 & d(s_i, m) \geq R_s - \mu \end{cases} \tag{2}$$

Here, $d_i = d(S_i, m) - (R_s - \mu)$, α is the physical device monitoring related parameter and μ is the uncertainty factor of the nodes. Redundant nodes are selected as a cluster heads which can completely covered by other nodes. The cluster head does not sense any information hence the energy for sensing and data synthesis can be reduced. If the death of nodes doesn't affect the coverage rate and sensing efficiency then the network performance will be high and energy consumption will be reduced. Point m will be sensed by the other N nodes in the monitoring area.

The NPS (Node public Sensitivity) of m:

$$NPS(m) = \sum_{i=1}^{N} P(s_i, m) = \sum_{i=1}^{N} e^{-ad} \tag{3}$$

NSC (Network sensitivity contribution) of node $S_i(x_i,y_i)$ to the number of nodes in the whole network:

$$NSC(s_i, m) = \frac{P(s_i, m)}{NPS(m)} = \frac{P(s_i, m)}{\sum_j P(s_i, m)} \tag{4}$$

The process for the selection of primary cluster heads:

$$NSC(s_i, m) = \sum_k \frac{P(s_i, m)}{NPS(m)} = \frac{P(s_i, m)}{\sum_j P(s_i, m)} \tag{5}$$

3.1.1. Primary Cluster head selection process

1. Wireless sensor network is initialized to cover the monitoring area.

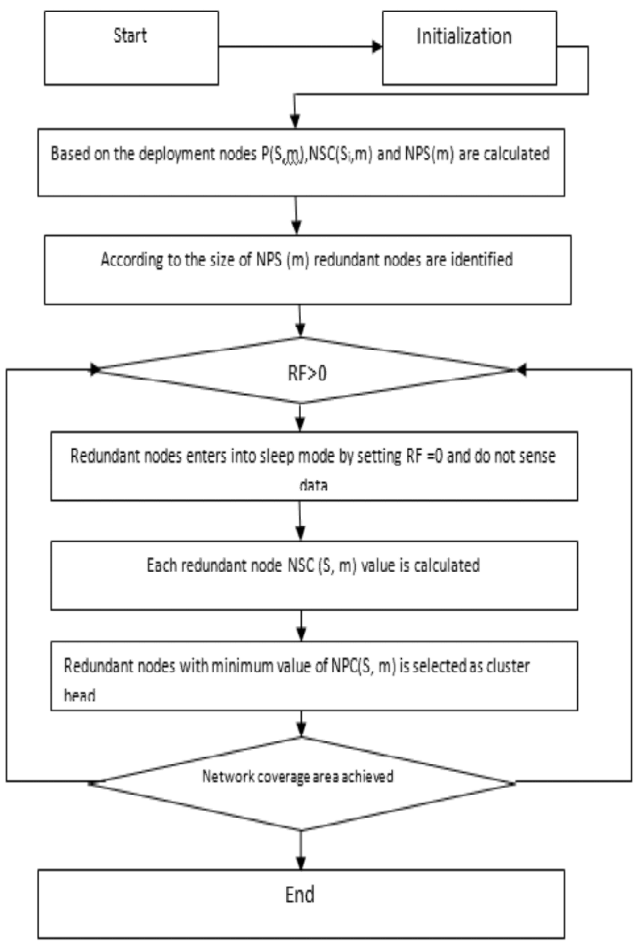


Figure 2: Primary Cluster Head selection Process

2. Obtain the network public sensitivity of each node using the formula (3)
3. Verify a node is the redundant node or not based on the size of NPS (n). Verify whether its redundant flag RF is 1.
4. The network sensitivity contribution of each node in the network can be calculated from the formula (2) and (3).
5. From the redundant nodes select the cluster head node. The NSC (S_i) of the cluster head node must be minimum.

For sleeping sensor nodes said the sensing intensity to 0 and the complete coverage of the network will be updated at the same time if the sensor node satisfy NPS($m>M_{min}$), then said the RF flag of this sensor node to 1.Cluster head will not sense data hence energy of sensitivity and data synthesis will be reduced. The flowchart is shown in the figure no. (4).

3.2. Secondary Cluster Head Selection Based on Survival Time Estimation

The highest energy consumption process is sending and receiving the messages. If one byte of message is transmitted and received then the energy consumption model will be:

$$P(s_i, m) = \begin{cases} 1 & d(s_i, m) < R_s + \mu \\ e^{-ad} & R - u \le d(s_i, m) < R + \mu \\ 0 & d(s_i, m) \ge R_s - \mu \end{cases} \tag{6}$$

After the death of primary cluster head, secondary cluster heads nodes are selected based on remaining nodes energy and the residual energy of the network. The node with higher residual energy will become the cluster head which will increase the network life time. For selecting the secondary cluster head, for each node we will calculate the residual energy (E_i).

To select the cluster head we need to consider both NSC and $E_{i.:}$

$$E_i = IE\ (i) - CE\ (i) \tag{7}$$

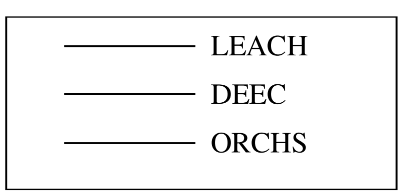
Where IE(i) is the initial energy and CE(i) is the current energy.

4. OPTIMIZED ROUTING

For optimized routing cluster head will select another cluster head to reach the BS(base station) or Sink. For selecting another cluster head, it will Consider minimum NSC value, maximum E(i) and minimum distance to reach the base station. Each cluster head node select forwarder cluster head to reach base station or directly communicate with base station for optimizing the routing.

5. SIMULATION RESULTS

Considering the simulation area has 800*800 m and base station is at the centre of the area. Now consider, time taken to transfer the information from cluster head to base station is 200 sec .Here 250 sensor node are deployed in the monitoring area and it is divided using Voronoi polygon method .Simulation is done in NS2 and threshold of the sensing probability is 0.3 .



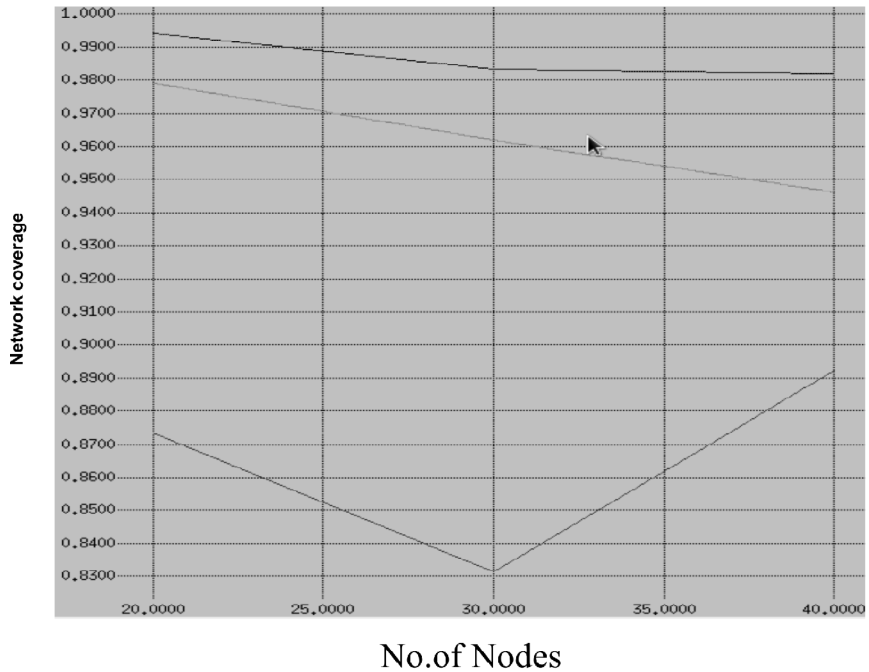


Figure 3: Coverage Simulation

Here we are comparing the coverage area of LEACH, DEEC and ORCHS methods .Graph is drawn between the Number of nodes and Network Coverage along X axis and Y axis respectively. From the graph it is clear that ORCH Protocol is covering more area compared with LEACH and DEEC Protocol. In 20 meters area ORCH is covering 99.43 % and DEEC is covering 97.91% and LEACH is covering 87.34% .From this we can say that ORCH is covering maximum area compared to LEACH and DEEC.

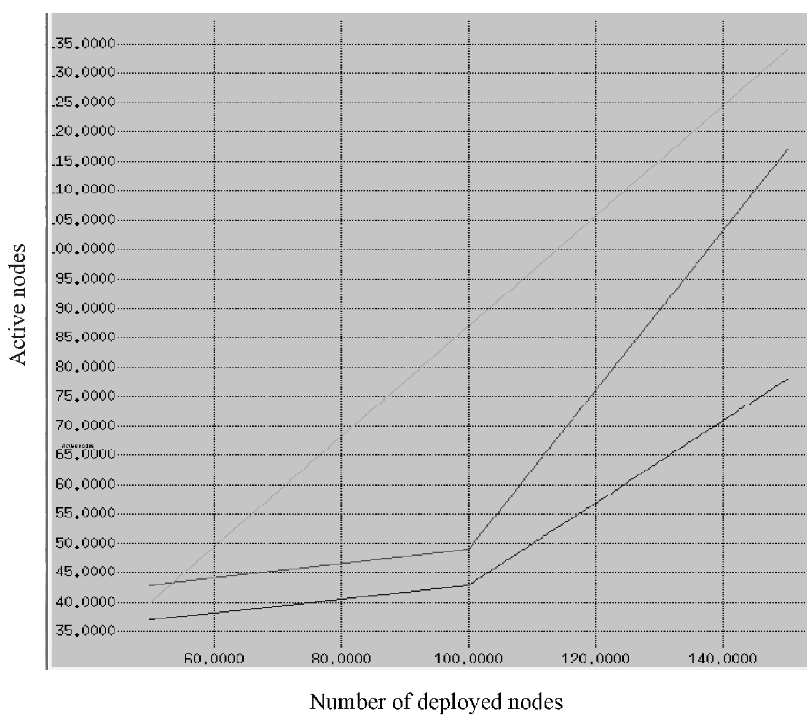


Figure 4: Total active nodes and deployed nodes

Considering the cluster heads and ordinary nodes are active nodes that do not fall into sleep mode. To select the cluster head nodes in LEACH, the random probability threshold (0,1) is used and in DEEC, cluster heads are chosen based on energy which is having some advantages in survival time and network coverage area. Least number of active nodes are required in the algorithm hence some redundant nodes are kept in sleep mode while selecting the primary cluster head. Figure 4, shows that graph between active nodes and total deployed nodes. Overall if 150 nodes area deployed, then 78 nodes are active in ORCHS and 117 nodes are active in LEACH and 134 nodes are active in DEEC. From this analysis it is clear that ORCHS has less number of active nodes compared to others.

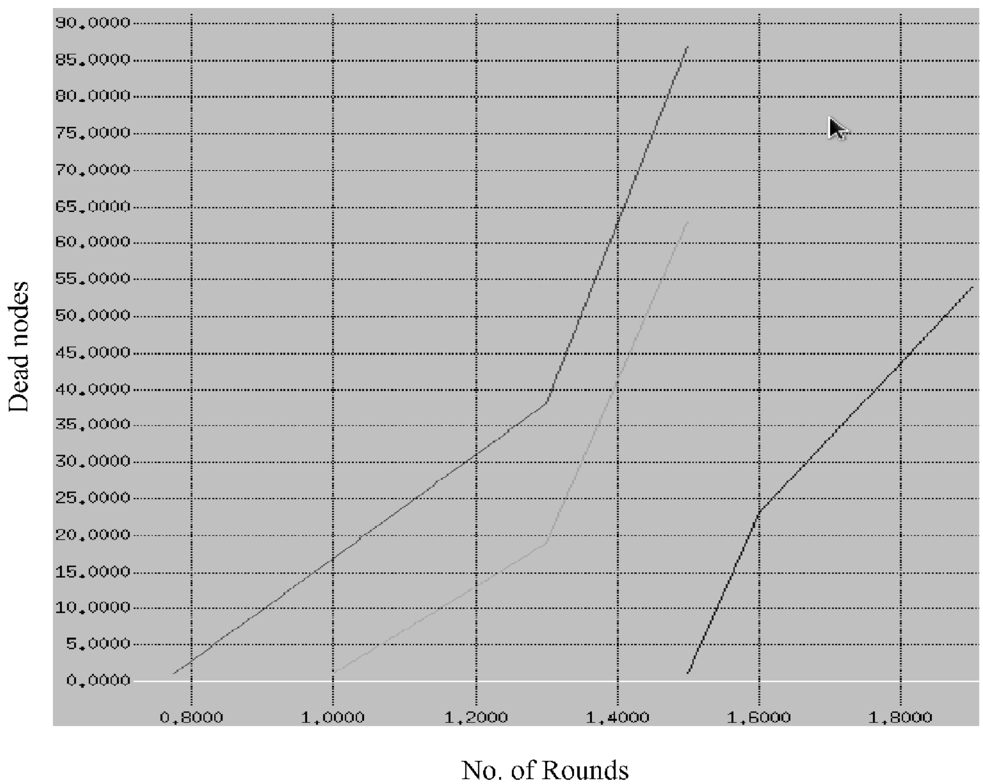


Figure 5: Nodes lifetime

In Figure 5 ,the nodes lifetime is shown .in LEACH the first Dead node appear at 750th round and in DEEC appears at 1100th round and in ORCH appears at 1600th round. From this analysis we can say that ORCHS performance is 56% more than LEACH and 26 % more than DEEC. The proposed method didn't shown much difference in case of coverage area but shown great difference in survival time. Proposed method is having the highest lifetime then other methods.

Figure 6 shows the average reschedule energy of the nodes. Here in this simulation we didn't consider the energy of this sleeping node to show the performance of the network because if one node dies it will be replace by reschedule node. Hence the number of nodes alive in primary stage is same. From graph we seen that average reschedule energy is gradually reducing in both LEACH and DEEC. But the proposed method has improved compared with this algorithm. The monitoring area is divided into cluster at the primary stage to keep some nodes in sleep modes so that energy consumption is reduced and the average reschedule energy of the network is stable due to sleep nodes .Hence ORCHS algorithm has a longer life cycle compared with other algorithm.

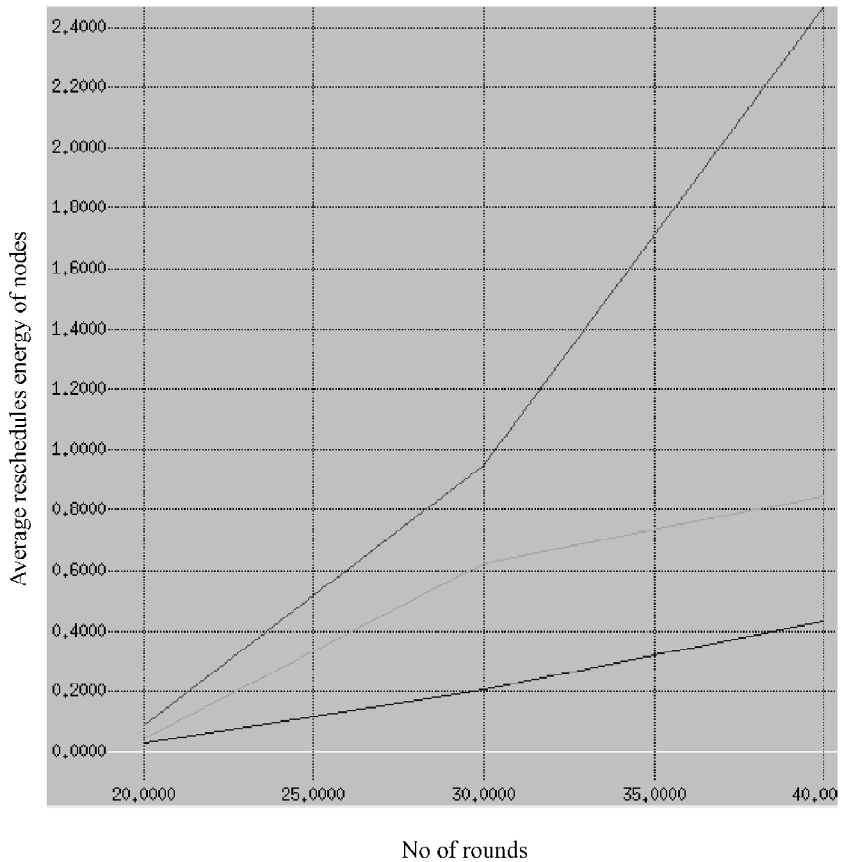


Figure 6: Energy consumption

6. CONCLUSION

An Optimized routing and cluster head selection protocol for wireless sensor network is introduced in this paper by analyzing the energy consumption of the sensor network using redundant nodes and energy non-uniformity. Experiments are done on average residual energy, active nodes, life cycle and coverage aspects. This method will overcome the disparity of energy consumption and in the transmission process, energy consumption is reduced, information redundancy is improved and life time of the network is increased.

REFFERENCES

[1] Rakesh kumar, Gurinder singh, "An Effective Approach for Minimizing Energy Consumption in WSN,"Indian journal of science and technology, 2016.

[2] K.Vijayan, Arun Raaza, "A novel clustering arrangement energy efficient routing protocol for wireless sensor networks,"Indian journal of science and technology, 2016.

[3] E.Thenmozhi, S.Audithan, "Energy Efficient cluster head selection and data convening in wireless sensor networks," Indian journal of science and technology, 2016.

[4] Mrs. R.U. Anitha, Dr.P.Kamalakkannan, "Energy Efficient Cluster Head Selection Algorithm in Mobile Wireless Sensor Networks,"presented at 2013 International Conference on Computer Communication and Informatics (ICCCI -2013), Jan. 04 – 06, 2013, Coimbatore, INDIA.

[5] Hosseinirad S M, Ali M M, Basu S K. "LEACH routing algorithm optimization through imperialist approach,"[J. International Journal of Engineering, Transactions A: Basics.2014.

[6] Zhezhuang Xu, Member, IEEE, Liquan Chen, Cailian Chen, Member, IEEE, and Xinping Guan, Senior Member, IEEE, "Joint Clustering and Routing Design for Reliable and Efûcient Data Collection in Large-Scale Wireless Sensor Networks," presented at IEEE INTERNET OF THINGS JOURNAL, VOL. 3, NO. 4, AUGUST 2016.

[7] Y. Han and Y. Tianming, "Adaptive energy optimized clustering algorithm for wireless sensor network routing," Appl. Res. Comput., Feb. 2015.

[8] S. M. Hosseinirad, M. A. Mohammadi, S. K. Basu, and A. A. Pouyan, "LEACH routing algorithm optimization through imperialist approach," Int. J. Eng., Trans. A, Basics, vol. 27, no. 1, pp. 39–50, 2014.

[9] Kiran Maraiya, Kamal Kant, Nitin Gupta, "Efficient Cluster Head Selection Scheme for Data Aggregation in Wireless Sensor Network," presented at Efficient Cluster Head Selection Scheme for Data Aggregation in Wireless Sensor Network.

[10] Wan Isni Sofiah Wan Din1, "Ranking Table for Cluster Head Selection of Wireless Sensor Network," presented at 2012 International Conference on Advanced Computer Science Applications and Technologies.

[11] Anindita Ray,Debashis De, "Energy Efficient Cluster Head Selection in Wireless Sensor Network," presented at 1st Int'l Conf. on Recent Advances in Information Technology | RAIT-2012.

[12] Ma Chaw Mon Thein,Thander Thein, "An Energy Efficient Cluster-Head Selection for Wireless Sensor Networks," presented at 2010 International Conference on Intelligent Systems, Modeling and Simulation.

[13] Shah R C, Rabaey J M, "Energy aware routing for low energy ad hoc sensor networks,"[C] Prof.Of the 3rd IEEE Wireless Communication and networking conf.(WCNC), Orlando, 2013.

[14] Fotouhi H, Alves.M, Zamalloa MZ, "Reliable and Fast Hand-Offs in Lower-power Wireless Networks [J]," IEEE Transaction on Mobile Computing, 2014.

[15] Javaid N, Wasee M, Khan Z A, "ACH: Away Cluster Head Scheme for Energy Efficient Clustering Protocols in WSNs," [c] saudi international electronics, communications and photonics conference, piscataway:IEEE 2013.

[16] Pan H, Zhang H F, Cid-Sueiro J, "Energy Efficient Target Tracking Algorithms in Wireless Sensor Networks,"[J] Journal of Computer Research and Development, 2010.

[17] Dongyao Jia, Huaihua Zhu, Shengxiong Zou, and Po Hu "Dynamic Cluster Head Selection Method for Wireless Sensor Network," IEEE Sensors Journal, Vol. 16, No. 8, April 15, 2016.