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Cluster Based Routing Protocol for Wireless Sensor Network

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Abstract - nowadays the wireless communication technologies are widely used across the worldwide to uphold the communication necessities for the end users. The wireless sensor network is formed by the number of detection stations which are regarded as nodes. Every node is generally of small, lightweight and portable. The main components of the sensor nodes are the transducer, microcomputer and power source. Generally, these networks are implemented in hazardous locations where it is very difficult to recharge and replace the power source. Again human monitoring scheme is also very risky there. Here energy consumption is the main issue because cluster-based protocols follow non-uniform node distribution. In this paper, we proposed to avoid such type of problem an energy-aware clustering algorithm (EADC) is proposed.

Keywords: cluster head, energy-aware clustering algorithm, energy efficient, wireless sensor networks, **Cluster node.**

I. INTRODUCTION

In wireless sensor networks, A number of self-organized sensor nodes compose the wireless sensor network (WSN). The main functionality of this kind of network is to perceive and gather data from the environment and to send them to users. The Low Energy Adaptive Clustering Hierarchy (LEACH) protocol, for instance, employs a hierarchical approach for clustering the network. There is an adopted cluster head for managing each cluster. The cluster head is in charge of several tasks; first, it is comprised of collecting data supplied from the members of a cluster on a periodical basis. It aggregates the data after gathering them. The next main task assigned to a cluster head is to directly transmit the aggregated data to the base station. The main objective of TDMA based schedule is to provide a particular time to each cluster member for data transmission. Cluster members learn the schedule and accordingly transmit data.

DRAWBACKS of LEACH Algorithm:

- In the LEACH algorithm, each sensor node randomly selects a cluster head and the energy consumption is high.
- Un-uniform distribution of cluster heads irrespective of residual make the network less energy efficient

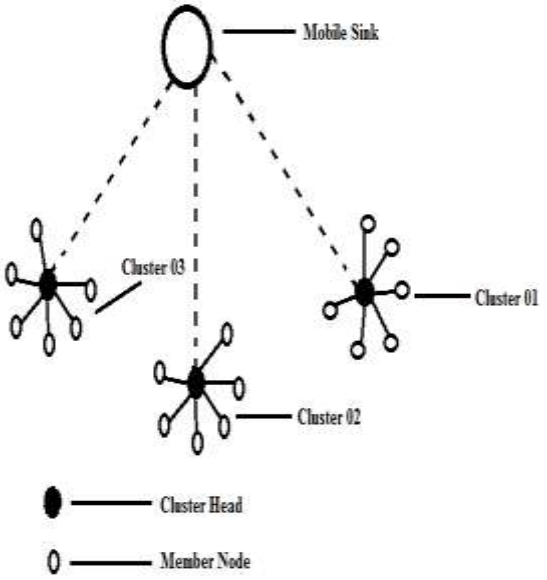


***Figure 1*: Cluster-Based WSN.**

II. EVOLUTION

In 2001, I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci studied about wireless sensor networks in which they describe the concept of sensor networks which has been made viable by the convergence of micro electro-mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the potential sensor network applications are explored, and a review of factors influencing the design of sensor networks is provided.

In 2002, Jason Lester Hill design System Architecture for Wireless Sensor Networks they present an operating system and three generations of a hardware platform designed to address the needs of wireless sensor networks. Their operating system, called Tiny OS uses an event based execution model to provide support for fine grained concurrency and incorporates a highly efficient component model. Tiny OS enables us to use a hardware architecture that has a single processor time shared between both application and protocol processing. They show how a virtual partitioning of computational resources not only leads to efficient resource utilization but allows for a rich interface between application and protocol processing. This rich interface, in turn, allows developers to exploit application specific communication protocols that significantly improve system performance.

In 2004, Bandyopadyay B, Coyle EJ, "Minimizing communication costs in hierarchically clustered networks of wireless sensors". In which Hierarchical clustering algorithm is imperative in expanding the lifetime of the network. Here the algorithm is made out of two stages, the setup stage and the steady stage. The main theme of the algorithm is how to choose the cluster head. Homogeneous clustering convention expects that all sensor nodes are outfitted with similar major of energy. As a result they can't take the upside of the presence of node heterogeneity. Adapting this approach a cluster head is chosen by the residual energy in every node.

Advantage: To increase the network lifetime.

Disadvantage: Cluster head election is done only based on the energy consumption.

In 2005, Gamwarige S, Kulasekere E. An algorithm for energy driven cluster head rotation in a distributed wireless sensor network. In this literature propose a distributed and energy driven clustering algorithm where the cluster heads are selected based on relative residual energy level of sensors. An Energy Driven Cluster-Head Rotation (EDCR) protocol initiates a CH rotation based on an energy driven event. Furthermore the algorithm uses localized communication within a limited neighborhood to select the node which has the most residual energy to become the CH, thus resulting in very low communication overheads during the selection phase of the algorithm. Furthermore, as the results will indicate, this has allowed the formation of well distributed CHs in the system. Further, the reduction in energy consumption of a node is achieved by initiating this localized communication protocol only at the point of CH rotation.

Advantage: Due to initiates the localized communication protocol, the overhead is reduced.

Disadvantage: Cluster head election is done only based on the energy consumption

In 2006 John Paul Walters, Zhengqiang Liang, Weisong Shi, and Vipin Chaudhary decribes As wireless sensor networks continue to grow, so does the need for effective security mechanisms. Because sensor networks may interact with sensitive data and/or operate in hostile unattended environments, it is imperative that these security concerns be addressed from the beginning of the system design. However, due to inherent resource and computing constraints, security in sensor networks poses different challenges than traditional network computer security.

In 2008, Jin Y, Wang L, Kim Y, Yang XZ. "Eemc: An Energy-Efficient Multi-Level Clustering algorithm for large-scale wireless sensor networks" This literature proposes an energy efficient multilevel clustering algorithm (EEMC) which is intended to accomplish least energy utilization in the network. In clustering processes the information accumulation activity is separated into rounds. Here each round starts with a cluster setup phase, which implies the node executes EEMC algorithm to form a multilevel clustering topology freely. Then in the data transmission phase the node transmits the sensed data packets to the sink node.

Advantage: To limit the aggregate energy spent in the network.

Disadvantage: This protocol faces high overhead.

In 2009 Chiara Buratti Andrea Conti Davide Dardari and Roberto Verdone their survey paper aims at reporting an overview of WSNs technologies, main applications and standards, features in WSNs design, and evaluations. In particular, some peculiar applications, such as those based on environmental monitoring, are discussed and design strategies highlighted; a case study based on a real implementation is also reported.

In 2010 Amar Adnan Rasheed M.S., Northeastern Dr. Rabi N. Mahapatra In their dissertation, they consider a number of security schemes for WSN (wireless sensor network) with MS. The schemes offer high network's resiliency and low communication overhead against nodes capture, MS replication and wormhole attacks. They propose two schemes based on the polynomial pool scheme for tolerating nodes capture: the probabilistic generation key pre-distribution scheme combined with a polynomial pool scheme, and the Q-composite generation key scheme combined with a polynomial pool scheme. The schemes ensure low communication overhead and high resiliency.

In 2011, Yu JG, Qi YY, "An energy-driven unequal clustering protocol for heterogeneous wireless sensor networks" It incorporates a distributed unequal clustering algorithm and energy driven versatile cluster head rotation mechanism utilizing unequal competition ranges to develop cluster of different size. The clusters which are situated at a greater distance from the base station are smaller than the clusters which are nearer to the base station. Here every node acts as the cluster head once just amid the entire lifetime.

Advantage: To improve network lifetime and to balance energy consumption.

Disadvantage: Cluster head election is done only based on the energy consumption

In 2012 Xuxun Liu In their paper they survey on Clustering Routing Protocols in Wireless Sensor Networks in which Based on network structure, routing protocols in WSNs can be divided into two categories: flat routing and hierarchical or clustering routing. Owing to a variety of advantages, clustering is becoming an active branch of routing technology in WSNs. In this paper, he present a comprehensive and fine grained survey on clustering routing protocols proposed in the literature for WSNs. We outline the advantages and objectives of clustering for WSNs, and develop a novel taxonomy of WSN clustering routing methods based on complete and detailed clustering

attributes. In particular, we systematically analyze a few prominent WSN clustering routing protocols and compare these different approaches according to our taxonomy and several significant metrics.

In 2013 R.U.Anitha and Dr P. Kamalakkannan, in their paper they developed Enhanced Cluster Based Routing Protocol for Mobile Nodes in Wireless Sensor Network they propose an enhanced algorithm for Low Energy Adaptive Clustering Hierarchy–Mobile (LEACH-M) protocol called ECBR-MWSN which is Enhanced Cluster Based Routing Protocol for Mobile Nodes in Wireless Sensor Network. ECBR-MWSN protocol selects the CHs using the parameters of highest residual energy, lowest Mobility and least Distance from the Base Station. The BS periodically runs the proposed algorithm to select new CHs after a certain period of time. It is aimed to prolonging the lifetime of the sensor networks by balancing the energy consumption of the nodes. Then compare the performance of our proposed algorithm with the cluster based protocols using ns2 simulator.

In 2014 Agam Gupta and Anand Nayyar studied about Cluster-Based Energy Efficient Routing Protocols in Wireless Sensor Networks, Wireless sensor networks (WSNs) consists of large number of multifunctional sensor nodes. Routing protocols developed for other ad hoc networks cannot be applied directly in WSN because of the energy constraint of the sensor nodes. Sensor nodes are battery powered and deployed in harsh environments so it is not always possible to recharge or replace the batteries.

In 2015 Jong-Myoung Kim, Seon-Ho Park, Young-Ju Han and Tai-Myoung Chung, designed Cluster Head Election mechanism using Fuzzy logic in Wireless Sensor Networks in which they introduce CHEF-Cluster Head Election mechanism using Fuzzy logic. By using fuzzy logic, collecting and calculating overheads can be reduced and finally the lifetime of the Sensor Networks can be prolonged. To prove efficiency of CHEF, they simulated CHEF compared with LEACH using the matlab. Our simulation results show that CHEF is about 22.7% more efficient than LEACH.

In 2016, Amit Goude & Priya Saxena, in their paper, Mobile ad hoc network is a most popular technology due to this ad hoc nature for research and development. Due to ad hoc nature of network nodes are randomly mobile and their topology is frequently changing thus each node co-operate with other to communicate. The dynamically developing topology is responsible for different kinds of performance and security issues in network. Additionally in this conditions the significant amount of resources are also consumed such as battery power, memory and processing capability. Therefore, the resource consumption and performance is a critical issue in this network. In this paper the resource consumption issues of MANET is investigated and for optimizing the resources more specifically energy a clustering based routing protocol is proposed. The paper also includes a detailed survey on the different energy preservation technique.

III. PROPOSED SYSTEM

The proposed cluster-based routing algorithm is an energy efficient clustering approach selects the cluster-head efficiently using the parameter remaining energy of the nodes. It can be considered, the higher the residual energy of sensor nodes selected as cluster-head. After selection of cluster-head (CH), sensor nodes that receive CH advertisement send join request to CH. If the node gets CH advertisement from two CHs, it will send join request to the CH that is in a minimum distance to it. After receiving join request, from the nodes, CH considers those as its members and prepares TDMA data transmission schedule for each of its members and broadcast the schedule. After receiving the schedule, each member broadcast data in its received schedule. After receiving the data from all of its members CH aggregates it and transfers it to BS.

Advantages

- It improves the network lifetime in the network.
- It reduces energy consumption.

IV. ARCHITECTURE AND BLOCK DIAGRAM

1. Architecture

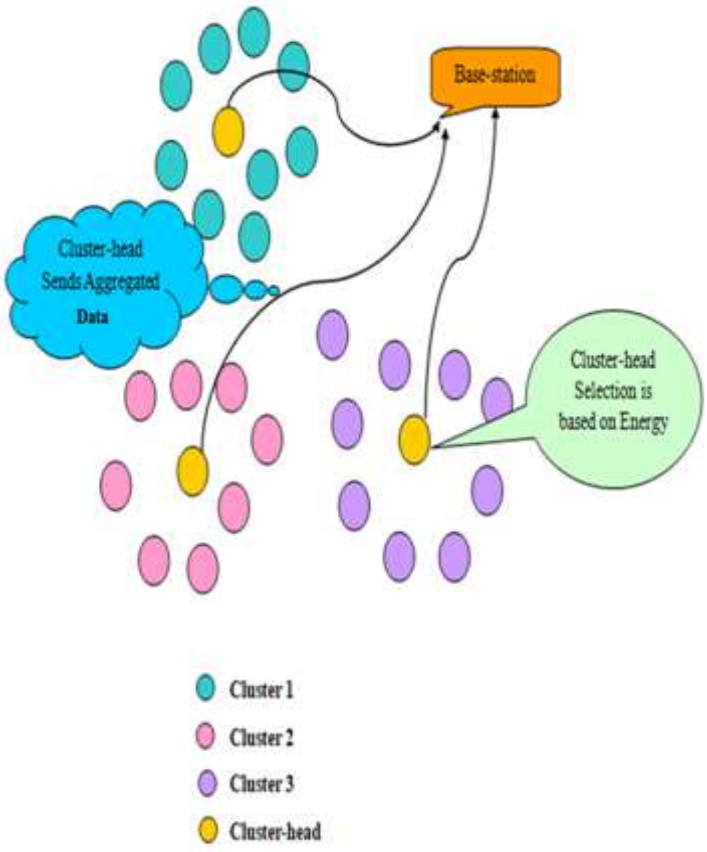


Figure 1: EADC_LEACH Based Cluster-Head Selection

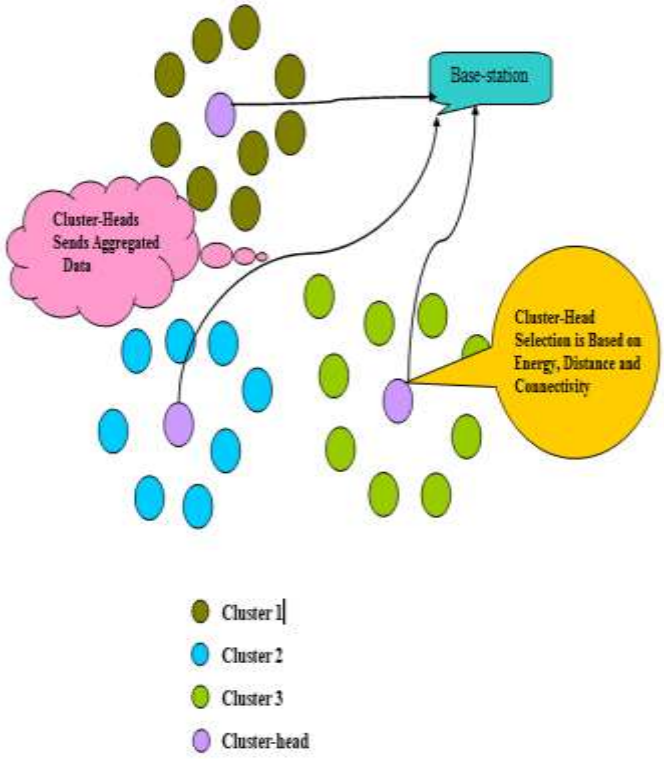
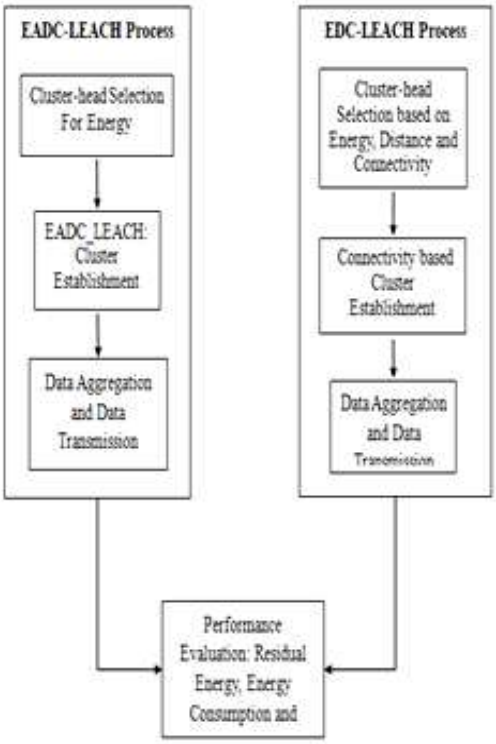


Figure 2: EDC_LEACH Based Cluster – Head Selection

2. Block Diagram



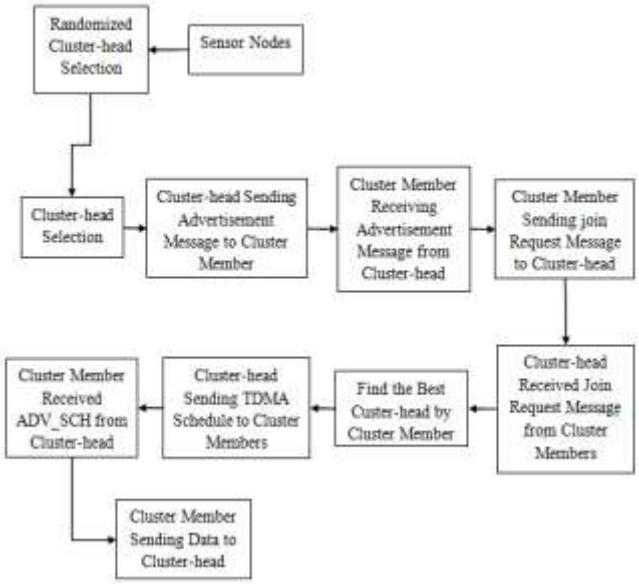
V. MODULE DESCRIPTION

- **LEACH: Clustering and Data Transmission**
  Input: sensors cluster formation, cluster head selection based on a threshold

Output: data aggregation and data transmission to the base station

The LEACH in this algorithm, each sensor node has randomly become a cluster head based on the considered probability function. It is worth mentioning that the role of being a cluster head is rotated among all sensor nodes and consequently the energy consumption of sensor nodes is balanced. Because of the random selection of cluster heads in the LEACH, it is highly possible that some of the cluster heads are very close to each other. Therefore, the non-uniform distribution of cluster heads in the monitored area is one of the main drawbacks of the LEACH. All sensors in a cluster are within the communication range of the cluster head. The cluster head interfaces the base station with the sensor network.

The cluster head is in charge of several tasks; first, it is comprised of collecting data supplied from the members of a cluster on a periodical basis. The transmission is directed through a single hop. Making a TDMA-based schedule is meant to allocate a schedule vacancy to each cluster to be utilized for transmission, is the primary job. The cluster members learn by the schedule when the cluster head disperses it. CH aggregates the data after gathering them. The next main duty assign to a cluster head is to straightforwardly transmit the aggregated data to the base station.



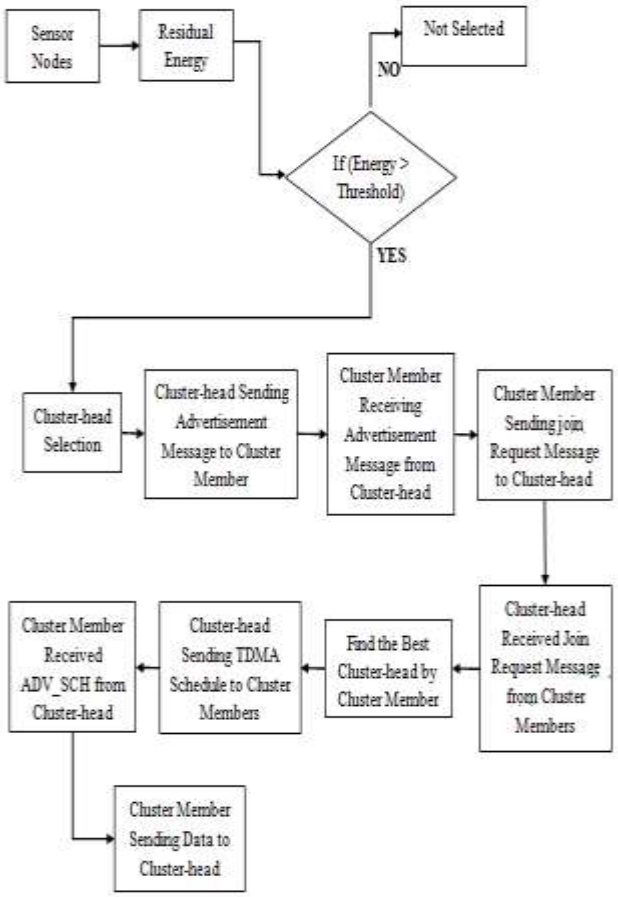
EADC based Clustering

Input: Sensors, Cluster Formation.

Output: Cluster-head Selection based on Threshold and Residual Energy.

In the energy-aware clustering algorithm EADC, The cluster head selection is based on higher residual energy, the parameter of cluster head competition in EADC is based on the ratio between the typical residual energy of neighbor

nodes and the residual energy of the node itself. Additionally, cluster heads broadcast head messages using the same competition range to create clusters of even sizes. Thus, the energy consumption among cluster members can be balanced well.



- **EDC-LEACH: Energy, Distance and Connectivity LEACH**
  Input: Connectivity, Residual Energy

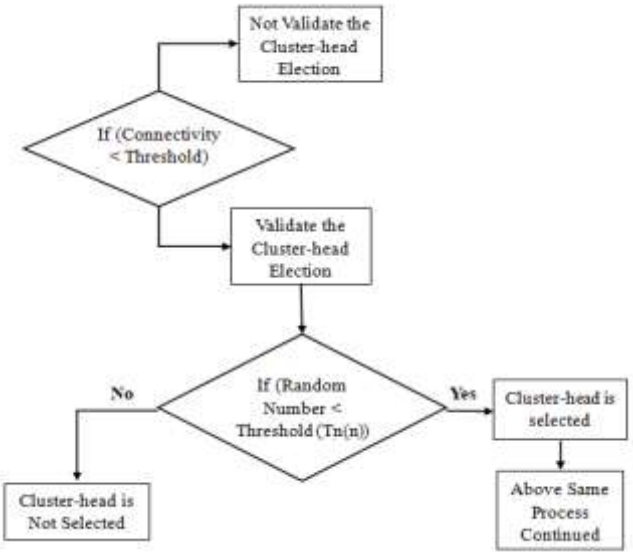
  Output: Cluster-head Selection, Threshold Calculation

  Connectivity factor is incorporated with residual energy and distance to sink that improves the clustering efficiency. It is measured as the inverse of the average distance with neighbor nodes. If the average distance is lesser it means that it has a high connectivity with neighbors. The node with high residual energy, low distance to the sink and high connectivity has a high probability to be elected as CH. Thereafter, data transmission and data fusion are carried out. After receiving the data from the CM, CH aggregates the data and sends it to BS.

  Connectivity = 1 / Average Distance of Neighbors

  Average Distance = Total Distance of Neighbor / Total Neighbor count

  (The threshold is based on Connectivity Value.)



VI. PERFORMANCE EVALUATION

Residual Energy

It is the average amount of energy remaining in the nodes after certain network operational period.

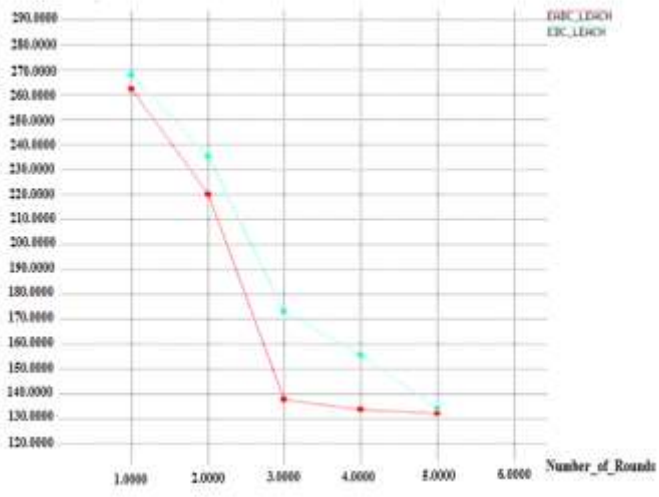


Fig 3. Comparison between the residual energy of EADC and EDC_LEACH

Here residual energy is taken along y-axis and number of around is taken along the x-axis. From the graph, it is clear that the amount of residual energy is higher in the proposed EDC_LEACH protocol than the existing EADC protocol.

Network Lifetime

It is the time period till half of the nodes in the network remain alive

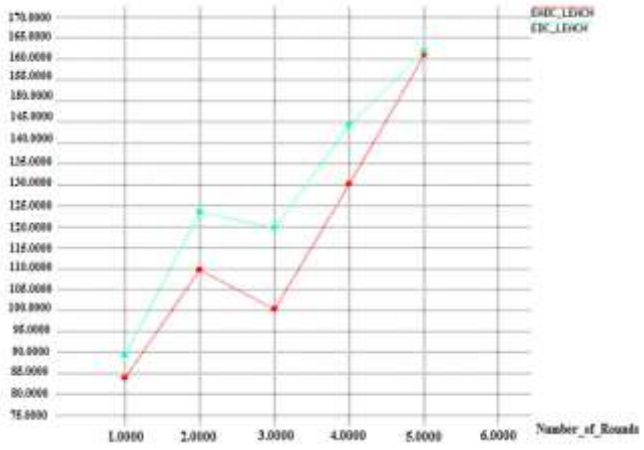


Fig 4. Comparison between the network lifetime of EADC and EDC_LEACH

Here network lifetime is taken along y-axis and number of around is taken along the x-axis. From the graph, it is clear that the network lifetime is increased in the proposed EDC_LEACH protocol than the existing EADC protocol.

VII. CONCLUSION AND FURTHER DEVELOPMENT

The proposed mechanism for cluster-based routing protocol for wireless sensor networks with non-uniform node distribution which contains an energy-aware clustering algorithm and a cluster based routing algorithm. The clustering algorithm balances the energy consumption among cluster members by constructing equal clusters. Inevitably, the energy consumption among cluster heads is an imbalance due to the non-uniform node distribution. Therefore, a cluster-based inter-cluster routing algorithm to balance the energy consumption among cluster heads by adjusting intra-cluster energy consumption and inter-cluster energy consumption. Each cluster head chooses a cluster head with higher residual energy and fewer cluster members as its next hop. The imbalanced energy consumption caused by non-uniform node distribution is solved by increasing forwarding task of the cluster heads in sparse areas. The contributed energy, distance and connectivity based clustering algorithm improves the performance in the network. Simulation results show that the improved algorithm can effectively reduce the energy loss and improve the network lifetime of the node, which greatly improves the overall performance in the networks.

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