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Development of an Adaptive Energy Aware Routing Scheme for Wireless Sensor Networks

Nauman Saeed Khan[1], Aamir Hussain[2], Mubashir Ali[3], Abdul Razzaq[4] and Amir Ijaz[5]

[1]Researcher, Department of Computer Science, MNS-University of Agriculture Multan, Pakistan.
[2]Assistant Professor, Department of Computer Science, MNS-University of Agriculture Multan, Pakistan.
[3]Lecturer, Department of Software Engineering, Lahore Garrison University, Pakistan.
[4]Assistant Professor, Department of Computer Science, MNS-University of Agriculture Multan, Pakistan.
[5]Lecturer, Department of Computer Engineering, HITEC University, Taxila, Pakistan.

(Corresponding author: Mubashir Ali)
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ABSTRACT: Wireless Sensor Networks (WSN) is used in extensive range of applications where is regular-network structure is infeasible. It is a real-time, new-generation system with restricted- energy assets, computation and memory. Due to restricted energy resources, the lifetime of sensor nodes directly effects the performance of the network. In WSN, Cluster Head (CH) selection and transmission strategy is very critical issue in clustering-based routing protocols because it directly effects the performance of WSN. Several different methods, techniques and schemes have been proposed to preserve the energy resources including clustering scheme, routing or transmission scheme and cluster head selection scheme. There is already work done on this issue but more contributions are required to increase the lifetime, energy, and efficiency of WSN's. In the proposed study we work on the unique idea of "Development of an Adaptive Energy Aware Routing Scheme for Wireless Sensor Network" and to improve transmission (routing) strategy we purpose new strategy of transmission (routing) called Partition Based Direct Communication with Routing Node Strategy. Research study has proved that Cluster Head selection based on single standard is not much energy effectual. Purposed scheme Cluster Head selection responsibility dedicate to Base Station and for selection purpose used multi-criteria with centralize Cluster head selection technique depend on Decision Making (MCDM) with Fuzzy-TOPSIS method. Due to Cluster Head selection and transmission (routing) schemes the-results elicit that the routing method recommended in our research-performs superior than prior scheme in terms of network-life, energy-efficiency, less cluster head-formation and the overheads of control traffic transmissions.

Keywords: Energy Efficiency, Enhancement of Life Time, Network Lifetime, Network Performance, Wireless Sensor Network.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) is used in a wide variety of applications where traditional-networking infrastructure is basically infeasible, it is a new-generation of real-time inserted systems with limited-computation, energy and memory-resources. The lifetime of network is directly affect due to limited energy resources. There for introduced several different methods, techniques and schemes for preserved the energy resources. Clustering Scheme, Routing Scheme, Cluster Head Selection Scheme, transmission technique, Load Balancing scheme are these schemes and techniques used for conserved the energy resources. All researchers have done good work on said energy issue but still work has been continued and do efforts to improve the energy, lifetime and efficiency of wireless sensor network. We have also participated in this effort and purposed a unique idea that is "Development of an Adaptive Energy Aware Routing Scheme for Wireless Sensor Networks" (AER). Clustering-plays a significant role to overcome andtosave the restricted energy sources of the installed sensor nodes, where nodes are managed into clusters and Cluster Head is an one node that is responsible to collect the data from remaining non-cluster head nodes, when collection of data the Cluster Head aggregated the collected data and send to Base Station. Cluster Head plays very important role for Communication between member nodes and Base Station. Cluster Head selection is very hot issue in clustering-based routing protocols because selection of Cluster Head is directly affected on the life time of the network. Study and research have showed that Cluster Head selection on single standard is not energy efficient [1]. So an ideal Cluster Head selection should be based on multiple criteria, so we do effort to propose a scheme which is covered many gaps of previous WSN's schemes like selection criteria and transmission method. In our purposed scheme Cluster Head selection responsibility dedicate to Base Station and for selection purpose used multi-criteria with centralize Cluster Head selection method based on fuzzy-TOPSIS technique [2]. The selection criteria base on four parameters like residual energy, node density, distance to the base station and average distance between a node and its neighbors. For outrank the potential nodes as Cluster Heads used Fuzzy Technique, it is Ideal Solution (Fuzzy-TOPSIS) method. To solve the decision-making problem in field of engineering and science used Multi-criteria methods with multiple attributes. Multi-criteria techniques match and rank numerous alternatives depend on degree of desirability of their respective attributes [3]. Different types of approaches should be used for Multi-criteria. Fuzzy set theory and Fuzzy logic is useful to decision making procedure. TOPSIS is a solution for several criteria optimization problem. TOPSIS was primarily proposed by Hwang and Yoon. Fuzzy-TOPSIS have m number of an alternatives and n number of attributes for each alternative with in a decision matrix.

II. RELATED WORK

Low-Energy Adaptive Clustering Hierarchy convention chooses conceivably too many Cluster Head at once or picks haphazardly Cluster Head for far from the Base Station without thinking about lingering vitality. In this situation such a significant number of Cluster Head channel their vitality early in this manner decrease the life expectancy of remote sensor arrange. As indicated by LEACH there is no understanding of Routing Node. Drain convention was producing for steering and it is soonest directing convention of WSN area [4]. With the progression of time numerous escape clauses distinguish in LEACH and reason their answer by numerous specialists, till now look into has been proceeding for its better improvement [5].

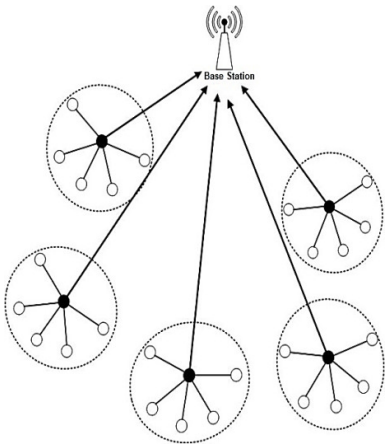

Fig. 1. Architecture of LEACH.

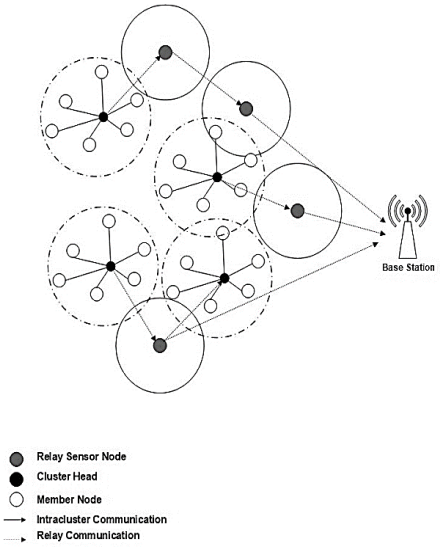

Fig. 2. Architecture of SEECH.

Scalable Energy Efficient Clustering Hierarchy convention was presented new idea of steering' because of new thought the vitality and life time of system was expanded. SEECH convention dependent on powerful bunching not a static grouping alike an AZR-LEACH, Cluster Head determination is a fundamental assignment in bunching base directing convention in this convention Cluster Head choice base on remaining vitality it mean which hub have high vitality level it is turned out to be chosen as a Cluster Head and the thought which is start in this convention is that the hub have second high vitality that is hub select as a Routing Node [6].

Group Head obligations are get information from non-Cluster Head hubs and in the wake of accepting the information a procedure keep running on this information called total. Group Head is total the information and after this procedure the information send to Routing Node. In following stage Routing Nodes are gotten information from significant Cluster Heads and send to Base Station.

Drawbacks of SEECH protocol is, Cluster Head determination criteria should be improved in light of the fact that this isn't adequate that Cluster Head criteria is depend just a single parameter, in the event that geo graphical area is additionally include choice system, at that point life time will be expanded [7]. The second point is that, there are whole exist in Routing Node choice criteria. In the event that a hub select as a Routing Node and its area was very a long way from Base station as contrast with pertinent Cluster Head at that point as per process the Cluster Head initially send the information to Routing Node and the Routing Node send the information to Base Station so this is the downside. On the off chance that we think severely, at that point understand that in the event that a Cluster Head specifically send the information to Base Station, at that point it is reason for the vitality preservation and improvement in life time of WSN.

A **General Self-Organize Tree-Base Energy-Balancing** Routing Protocol is figuring for vitality protection and increment life time of WSN. The same number of different conventions which is produce for WSN their creators asserted that created convention are vitality safeguarding and life time of system so comparably GSTEB likewise present new thought for above examined parameters improvement the primary point of GSTEB is to accomplish a more drawn out system lifetime for various applications. In each round, Base Station chooses a root hub and communicates its ID and its directions to all sensor hubs. At that point the system processes the way either by transmitting the way data from Base Station to sensor nodes or by building of same tree structure by each node separately and dynamically. In each preceding case, in less time and with minimum energy usage, GSTEB can alter the root and rebuild routing tree [8]. Consequently, in comparison to other protocols a well-balanced load is attained. The process of GSTEB is separated into Preliminary Phase, Tree Raising Phase, Self-Organized Data Collecting, Information Exchanging Phase and Transmitting Phase.

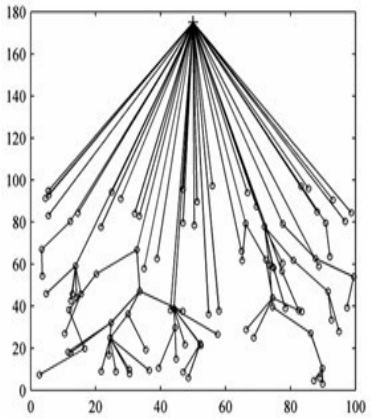

Fig. 3. GSTB.

The Author introduces in this paper a novel geographic routing protocol called **Energy-Efficient Geographic Routing (EEGR)** for wireless sensor networks. In EEGR, both geographic data and handset control qualities are utilized to settle on sending choices, accordingly empowering a vitality mindful limited steering system. Geographic steering, in which every hub advance bundle just dependent on the areas of itself, its coordinated neighbors and the goal, is especially alluring to control obliged sensor systems. The limited idea of geographic directing kills the overhead brought by course foundation and support, demonstrating the upsides of humble memory prerequisite at every hub and high adaptability in vast conveyed applications [9]. Be that as it may, most recently proposed geographic steering plans usually utilize avaricious separation-based measurements to settle on directing choices. For example, in GRS, every hub basically advances the bundles to its neighbor which is nearest of the goal. According to MFR, bundles are constantly sent through the highest advancement (i.e., anticipated separation on the conventional line concerning goal) to the neighbor. In spite of the effortlessness and adaptability of such plans, they can't ensure that all bundles are conveyed in a vitality productive path since the factor of vitality scattering isn't considered when settling on sending choices.

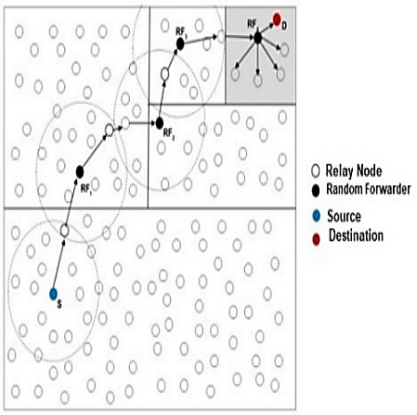

Fig. 4. EEGR.

Multi-criteria based appropriated CH choice strategy dependent on fluffy TOPSIS technique. Improve lacks in past fluffy based CH determination system. Because of utilizing dispersed calculation, hubs themselves accept choice to be chosen as CH, subsequently hubs join CH with greatest assets since all hubs have file estimation of their neighboring hubs (which is a rank esteem gotten utilizing multi-criteria, last CH determination depends on this esteem) [10].

Characterize a limit an incentive for variation of Cluster Head, so in this suggested plan Cluster Heads are not varying in each round, the reason of overhead control is greatly lessened when contrasted with past plan. Deliberate 4th criteria with leftover vitality, No. of neighbor hubs, and separation from Base Station and normal separation structure neighbor hubs. This plan comprises of four stages, for example arrange organization, neighbor revelation, CH determination and bunch development and last one is correspondence [11].

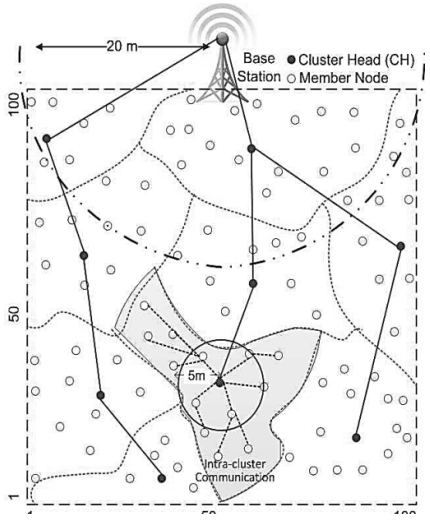

Fig. 5. MCDM.

III. PROPOSED SCHEME

Several methods can be found in cluster base routing scheme. The basic purpose of this schemeisto proficiently consume the energy relating to protractnetwork life time as well as constancy. Conduct a detailed debate in this section for discussed particulars of the suggested scheme that is one of selection of Cluster Head through Multiple Criteria Decision-making (MCDM) and other is transmission (routing) strategy.

We suggest a multi-criteria Cluster-Head selection scheme centered on centralize algorithm which is used fuzzy-TOPSIS-method and mend lacks in earlier fuzzy based Cluster Head selection-scheme. Because using of centralize-algorithm, nodes cannot proceeddecision themselves nominated as a Cluster Head[12]. BS will select a node as a Cluster Head on base of index rate (index rate is rank value based on multi-criteria, finally Cluster Head nomination is depending on this value) and join all Non-CH nodes to Cluster Head. For change of Cluster Head, we define a threshold value, therefore Cluster Heads (CHs) do not vary in every round in our proposed scheme. Furthermore, introduced new transmission (routing) strategy for sending data. In this context, overhead control-is really decrease compared as per to prior schemes. We ruminate four parameters for selection of cluster head that are density of nodes in a particular coverage area, the residual-energy of nodes, farness of nodes-from the BS (Base-Station) and the mean gap of a node from its neighboring nodes. Our suggested scheme resides of four phases, i.e. network deployment phase, information exchange phase, Cluster Head selection & cluster-formation phase and last one is transmission (routing) phase [13].

Network Deployment Phase

In showing Fig.: the basic structural design of WSN's used in proposed scheme. We will spouse or assume that installation of the sensor nodes in network field in form of random and homogeneous. Furthermore, also suppose that coordinates related to Base Station are known same as set dimensions of the sensor field. The Base-Station have following capabilities: - (1) Receiving (2) Aggregating (3) Sending the data to preferred ends.

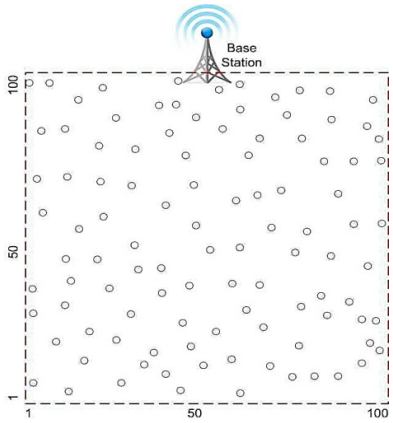

Fig. 6. Sensor-Nodes-installed in Field.

Information Exchange Phase: The primary step according to suggested routing scheme is the nodes transmit their specific info to Base Station. Initially nodes send Hellopacket, that is take ID of node, C1 node residual-energy, C2 density of node, C3 farness to Base Station and C4 mean space among particular node towards its neighbors and locality info. Initially, each node has no data qua its adjacent nodes so in starting C2 and C4 grounds into the Hello packet will be blank [14].

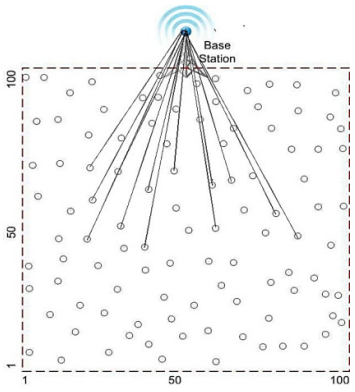

Fig. 7. Nodes send their specific information to BS.

Though, after sending Node ID and location info with BS. The BS computes C2 and C4. After receiving hello packet from particular nodes, Base Station build a table (T) of that nodes, parameter necessary for table building are ID of adjacent node's C1, C2, C3 and C4 along with its info. There are assume thatn nodes which are under the authority of BS, then T_b will be an (n+ 1) × 4 matrix, as shown below

$$T_b = \begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_{n+1} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 \end{array} \\ \begin{pmatrix} v_{1,1} & v_{1,2} & v_{1,3} & v_{1,4} \\ v_{2,1} & v_{2,2} & v_{2,3} & v_{2,4} \\ v_{3,1} & v_{3,2} & v_{3,3} & v_{3,4} \\ \vdots & \vdots & \vdots & \vdots \\ v_{n+1,1} & v_{n+1,2} & v_{n+1,3} & v_{n+1,4} \end{pmatrix} \end{array}$$

Process for CH Change: Once clustering round is successful, all follower nodes start regular communication in clusters through their particular CHs. the BS monitor rank index value of the CH's and along with set a through hold value during the normal communication, for control the change of CH in each round. If a CH rank index value plus precise threshold (in our suggested scheme it is 0.1) is reduce as compare to any other node which is participate in election process then the BS announce and conduct re-election procedure inside the cluster according to succeeding steps which is deliberated above, during this CH will no more be authorized to be perform as CH [15]. Continue this process till last final node will expires in the network. Cluster Head change-flow diagram is shows in Fig. 8.

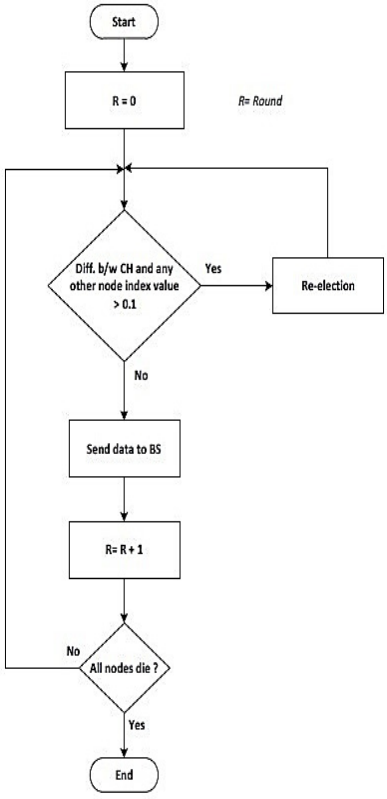

Fig. 8. Procedure for change CH.

Transmission (Routing) Phase: When Cluster Head selection and cluster creation, the transmission phase is started. The **Partition Based Direct Communication-with Routing Node Strategy** process is deliberated by our suggested scheme for the reason that it is more practical and realistic one. In a cluster the nodes inside range of Cluster Head, transmit their data straight to their respective Cluster Head [16]. The Cluster Heads in twenty meters range of Base Station, transmission straight to Base Station, while the outstanding Cluster Heads that is lie in that part of network which is far away from BS those CH send their data to BS with the help of Routing Nodes, in this context first of all CH gather and combined data from Non-CH's nodes and then directly forward data to related RN in cluster.

The Routing Node receive data to related CH and forward to BS directly. We introduced new transmission technique for cover the lot of loop holes in previous techniques, so the purpose of using **Partition Based Direct Communication with Routing Node Strategy** is toward growth of network solidity and life-time. Fig. 9 demonstrates inter and intra cluster transmission (routing).

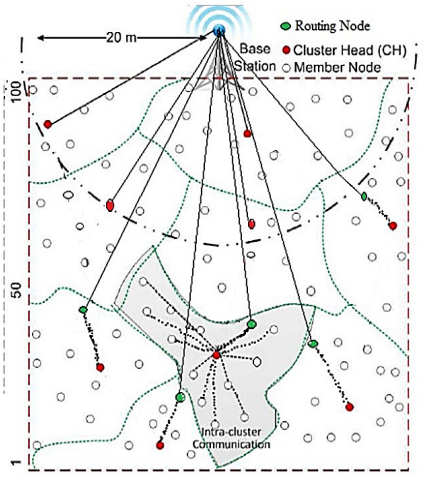

Fig. 9. Intra and Inter-cluster Communication.

Due to divide network field into two parts we achieve lot of benefits like lifetime of network and control the deformation process of nodes. Realistically those CHs which are near to BS. energy consumption during transmission is very less as compare to those CHs which are far to BS because when these CHs throw data to BS its consumption of energy are high due to long distance [17]. So in this context create Routing Node for support of those CHs which are far to BS. Firstly CHs gather data to their respective nodes and then those CHs which are far to BS send data to Routing Nodes and the RN's are directly forward data to Base Station, after this transmission cycle is completed then repeat this process or cycle till death of end node. Comprehensive flow diagram of suggested scheme, including Rank Index calculation, Cluster Head selection and in cooperation inter and intra-cluster transmission (routing), is shown in Fig. 10.

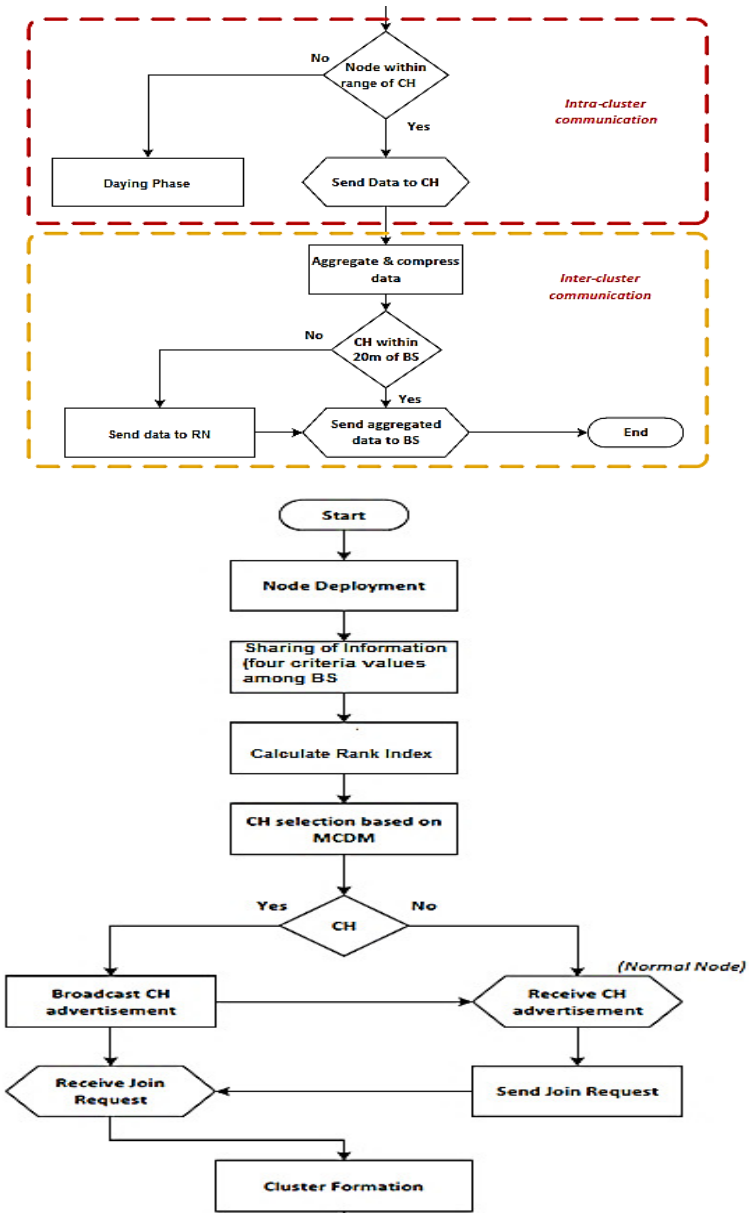

Fig. 10. Flow Diagram of Proposed Scheme.

IV. RESULTS AND DISCUSSION

Through simulation tool using MATLAB we conduct performance comparison between previous FUZZY based Cluster Head selection scheme, LEACH and our suggested scheme AER. In this part results of the proposed research study are concisely discussed and analyzed. We observing the numbers of rounds till first node died for calculate the solidity of the network. Simulations results of our suggested scheme are compared with previous schemes are showing in following farther graphs.

Number of Dead Nods: In network No. of dead-nodes in every round are shows as Fig. 11. In LEACH first node dies around 713 rounds, it is clear from graph, according to earlier fuzzy model dies 1st node around 915 rounds, and however in suggested scheme dies first node 2373 rounds. In our purposed scheme it shows that stability and network lifetime is much sound than old clustering and routing schemes. Basic cause for this LEACH is based on a single standard, however earlier fuzzy-TOPSIS method every node itself take decision for CH, it is energy intensive process considering the knowledge of neighbor nodes, because all nodes maintain neighbor table, thus this process required and consume massive energy.

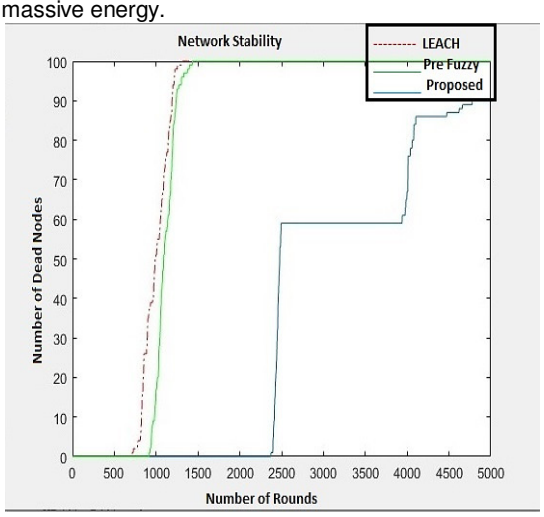

Fig. 11. Number-of Dead-Nodes.

In our purposed scheme BS perform CH selection procedure on basis of four parameters like density of nodes in a particular coverage area, the residual-energy of nodes, distance of nodes-from the Base-Station and the average-distance of a node from its neighboring nodes. The life time, stability and whole energy efficiency of the network is increase due to consume less energy for selection of CH.

Number-of-Alive-Nodes

Network lifetime graph shows Fig. 12. Last node dies in LEACH around 713 rounds, nodes dies in previous fuzzy model 915 rounds and according to suggested AER scheme dies the network afterward around 2373 rounds. Due to use of MCDM for Cluster Head selection and transmission (routing)strategy in our suggested AER scheme the life time of network is-greatly enhanced than prior schemes.

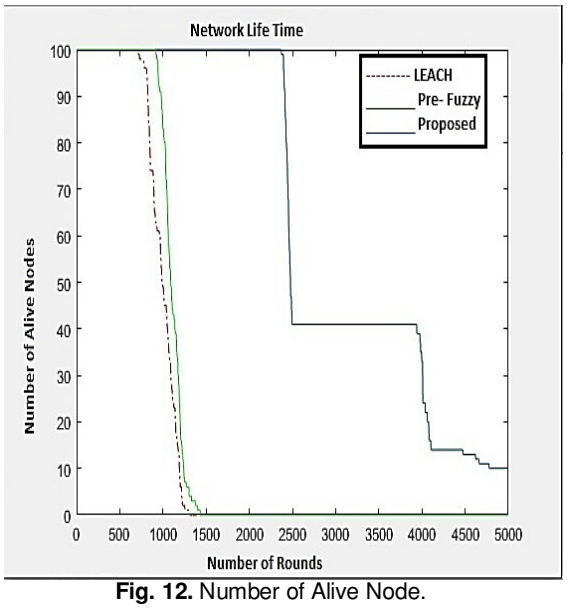

Fig. 12. Number of Alive Node.

Packets-Sent-to Base-Station: Shows as Fig. 13 the ratio of received packet at Base Station. Due to low energy utilize in selection of Cluster Head and transmission (routing) model, throughput network of our suggested scheme-is-much better than prior schemes.

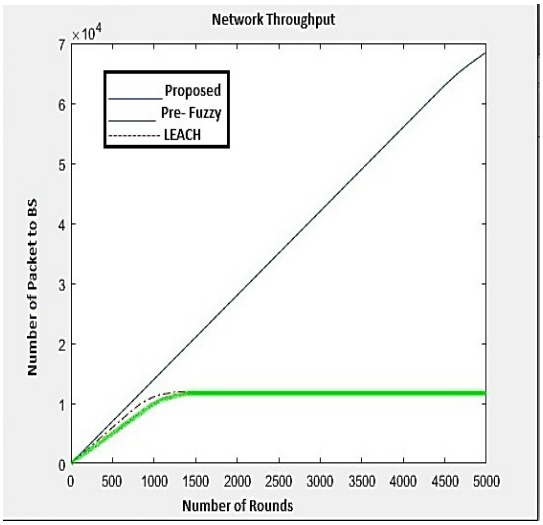

Fig. 13. Packets sent to BS.

Change of Cluster Head: Some key disadvantage of LEACH is that in every round or communication cycle it performs CH election process. Hence if it is distributed then all nodes send their whole information to BS in each round. Nodes exchange their info with all neighbor nodes in each transmission cycle, if centralized algorithm, like C-LEACH. Require control overhead packets for exchange this info or transfer data to BS in each round. Hence in each round protocol required have massive number of overhead-control- packets for process of re-election of Cluster Heads selection, consequential in extra energy depletion.

According to suggested scheme we describe a value of threshold, if variance the threshold or index rate among Cluster Head and any others node (which is participate in election process) is go above that

threshold then only this condition the CH will change. There are required very minor No. of control-overhead packets due to slight number of deviations in CH. The number of CH variation during every round shows in Fig. 14.

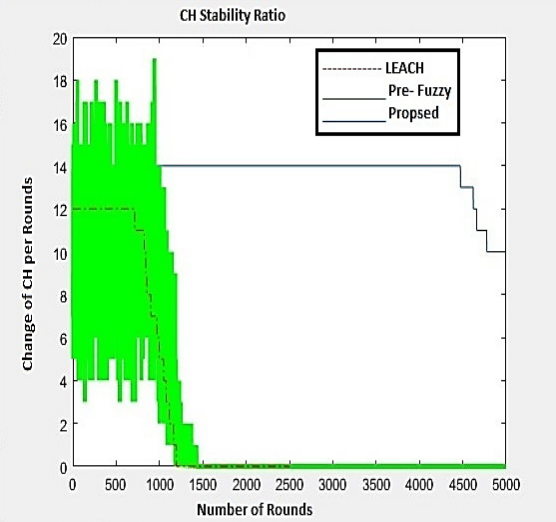

Fig. 14. Change-of-Cluster Head's.

V. CONCLUSION AND FUTURE WORK

In this research study present a cluster-based routing scheme for wireless sensor network. Cluster-Head selection is very hot topic in clustering based routing protocols because selection of Cluster Head is directly effect on the life time of the network in this context in purposed scheme Cluster Head selection responsibility dedicate to Base Station, because BS has no issue of energy and for selection purpose used multi-criteria with centralize Cluster Head selection process based on fuzzy-TOPSIS method. It means sensor nodes do not take decision themselves to become as Cluster Head. The selection criteria base on four parameters like density of nodes in a particular coverage area, the remaining-energy of nodes, distance of nodes-from the Base-Station and the average-distance of a node from its neighboring nodes. Frequently Change of Cluster Head in every round becomes bad impact on performance of network so avoid to change of CH in every round using significance value of threshold. BS announce re-election process for CH select in inside the cluster when rank index value and precise threshold value (which is 0.1 in suggested scheme) of any Cluster Head is reduced as compare to any other node which is participate in election process. In this condition the previous CH will no more authorized to be perform as CH. Till last node dies in the network this procedure will continue. Transmission (routing) strategy plays important role in the lifetime of WSN therefore we develop a new transmission (routing) strategy "**Partition Based Direct Communication with Routing Node Strategy**". According to transmission (routing) strategy those CHs communicates directly to BS which are within twenty meters range of BS, whereas the remaining CH's perform indirect transmission towards BS with the help of Routing Nodes, in this context first of all CH gather and combined data from other-nodes and then directly send data-to RN in cluster. The Routing Nodes received data to their respective CH's and forward to BS directly.

For performance comparison of AER with LEACH and pre-Fuzzy scheme we use MATLAB simulation tool. As per results the overall performance of AER is too good. Hope so further improvement can be possible in future if increase no. of Base Stations in network field.

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Conflict of Interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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