EERP: Intelligent Cluster based Energy Enhanced Routing Protocol Design over Wireless Sensor Network Environment

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Abstract—Wireless Sensor Network (WSN)) and the associated technologies are growing day-by-day in a drastic level. The Wireless Sensor Network medium has a distributed communication logic, in which it is interconnected with set of wireless sensor nodes and a unique basestation. A basestation stays in a constant place to provide a support to the transceivers for achieving a successful communication between source and destination entities. This kind of wireless communication mediums highly depends on the basestation to acquire the transaction needs as well as the basestation acts as a gateway between transmitter and receiver units. The cluster based wireless communication models are introduced to provide a flaw free communication between entities on WSN region with handling of wireless sensor nodes in the form of cluster. In literature several cluster enabled wireless communication models are designed, but all are strucked up with improper node placements and associated energy level mismatching. These issues raise cost efficient problems in Wireless Sensor Network environment. SO, that a new energy efficient routing protocol with an effective communication strategy is required to solve such issues in past. This paper introduced a new routing protocol with high efficient data transmission norms, in which it is called as Energy Enhanced Routing Protocol (eeRP). The proposed approach of eeRP associates the powerful clustering logic in this scheme to provide a fault free communication model to the WSN environment. By using this approach the standardized routing model is constructed with respect to the sensor nodes and basestation. The most important part of cluster based wireless communication model is the handling of Cluster-Head (CH), in which it needs to be elected based on certain communication principles such as the estimation of distance, position of other nodes in the cluster region, basestation positioning and the node capability. These constraints are essential to analyze the Cluster-Head to improve the pathway estimation process. The proposed approach of eeRP utilizes the powerful CH election algorithm called Firefly to provide an intellectual cluster head election process. The performance level of the proposed approach eeRP is estimated based on the efficiency of throughput, path selection efficiency, reduced energy consumption ratio and the network lifetime improvement. The experimental results assure these metrics in resulting section with graphical proofs.

***Index Terms*:**Wireless Sensor Network, WSN, Energy Enhanced Routing Protocol, eeRP, Cluster, Energy Efficiency, Firefly, Cluster Head

I. INTRODUCTION

The energy considerations are the major concern of Wireless Sensor Network, in which it is purely operated based on battery power. The power level of the battery will be drained over a period of time, so that the need for transferring the data in big size is still a problem to deal with. The over burden to nodes to take care of battery oriented issues and complexity leads to the node lifetime complexities as well as leads to network failures. The clustering logic is introduced to deal with such complexities and it is already mentioned in several literatures as well [1][2]. The battery backup ratio, sensor nodes lifetime and the network lifetime level will be getting increased by using such cluster based routing platform. Such process of cluster based routing requires proper Cluster Head (CH) and it is the most important task of all cluster regions to elect the proper Cluster-Head, in which it is the most important concern of energy efficiency [8]. This kind of efficient cluster head election process improves the network lifetime and reduces the overall network delay ratio in Wireless Sensor Network. The Cluster-Head election process is the crucial task in WSN environment as well as it depends on several metrics such as energy efficiency estimations, end-to-end delay considerations, node distance ratio analysis and the cluster privacy considerations [9]. This paper applies a Firefly cluster head election algorithm to select the prompt cluster head with all specific considerations. The cluster head election process improves the overall network lifetime and the energy efficiency while communication happens between transmitter and receiver [3][4], so that the energetic wireless sensor network optimization scheme need to be utilized over the proposed approach of Energy Enhanced Routing Protocol.

This Firefly algorithm estimate the optimization logic in electing the cluster-head as well as the energy efficient routing metric is introduced such as eeRP to deal with complex communication scenario as well. The wireless communication based network routing protocols are categorized into two different variations such as Homogenous Routing and Heterogeneous Routing. The homogenous routing protocols provides a static routing environment with fixed number of sensor nodes and the same energy level is considered to all sensor nodes for communication. The scalable ratio of this approach is more complex due to the following lacking such as Network Packets Control Overhead, energy level variations because the network range increased means the similar energy requirement level also increased in parallel [5]. The hierarchical routing concept is completely differing from the homogenous metric, because the hierarchical routing concept split the routing areas into number of cluster units. Each and every cluster block contains a Cluster-Head sensor node, in which it is used to accumulate the data from the local cluster and passed to the base station for processing and the details are forwarded to the respective cluster head of the recipient to reach the destination [6][7]. This kind of heterogeneous wireless network formation improves the lifetime of nodes presented into the wireless sensor network environment as well as it improves the network lifetime as well. The overall energy consumption level of the proposed approach is highly reduced due to the appliance of Firefly algorithm in association with Energy Enhanced Routing Protocol. The following are the most important issues to take care on handling with Wireless Sensor Network communications [10][13].

(i) The repeated election of same cluster node as a cluster head causes the node lifetime lo low and it leads the network lifetime reduction.

(ii) It is not possible to confirm the standard form of selecting the cluster-head in uniform manner as well as the same cluster consists of different cluster heads leads to a network collision, in which it automatically cause the network performance degradations with less efficiency in communication behavior.

(iii) The cluster network is considered to be the distributed network, in which the nodes that are left unused by the cluster head leads to the improper workload allocation problems as well as the unused sensor nodes even expects sufficient energy for surveillance.

(iv) The commonly used shortest path routing metrics are not suggested for such case of cluster-based routing scenario as well as the common cluster-based transmissions not follow these kinds of shortest path metric in communication between Cluster Head and the base station.

In this paper, the proposed approach of Energy Enhanced Routing Protocol in association with Cluster management principles such as Firefly is introduced to resolve all such wireless communication-based issues in proper manner with energy efficiency preservation-based data transmission logics. The following are the major contributions of the proposed approach, in which those are explained in detail further.

(i) To design a new unique cluster-based routing model with optimized communication framework with novel routing protocol called eeRP.

(ii) To follow the intelligent Cluster-Head selection process by means of associating the Firefly CH selection algorithm with eeRP to provide better routing process.

(iii) An initial energy level constrain of the nodes within the cluster are defined with 0, so that there will be no energy wastage occurred for managing the idle nodes.

(iv) The intent is to design the cluster framework is to support both inter and intra cluster communications over Wireless Sensor Network environment.

(v) Performance metrics are evaluated with the concerns of improved throughput ratio, path selection efficiency, and improvements on Frame Success Ratio (FSR), Energy Preservation Ratio and the Network Lifetime.

The following figre, Fig-1 illustrates the clear view of Wireless Sensor Network Cluster formation and the associated specifications such as how the cluster node is communicating with cluster head and the cluster head commnication with basestation. Once the data packets reached the basestation, the BS analyses the incoming packets address and find out the respective cluster head to forward the respective dertails further.

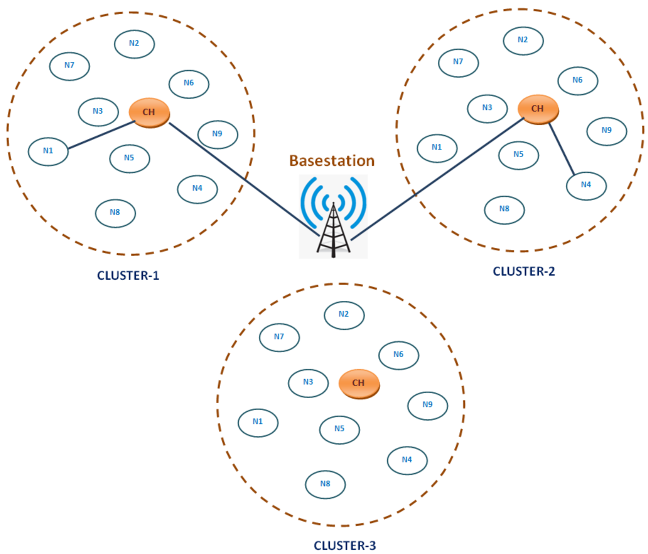


Fig.1 Cluster based Routing Environment

The rest of this paper describe regarding Related Study over section 2, further section of Section 3 illustrates the proposed system methodologies in detail with proper algorithm flow and the Section 4 illustrates the Result and Discussion portion of the paper and the final section, Section 5 illustrates the concept of Conclusion and Future Scope of the proposed paper. These all will be explained in detail over the further section summaries.

II. Related Study

In 2020, Mojtaba Shirazi' et al., [11] have proposed a paper related to Wireless Sensor Networks power consumption norms with respect to hierarchical architecture and the concept of new routing protocol called MEACBM was introduced to provide a support for mobile sensor nodes. In this paper [11], the authors illustrated such as a hierarchical energy restrained wireless communication network with respect to distributed estimates are recognized based on random source. Sensors send their measurements to a CH node within each cluster (CH). CHs fuse received signals optimally and relay orthogonal fading channels to the fusion center (FC). To activate estimated channels at the FC, CHs send pilots before transmitting data. The mean square error (MSE) referring to the FC source's linear minimum average square error, is determined and the Bayesian Cramér-Rao bound is obtained (CRB). Our objective is I to find the optimum training capability, (ii) the optimal power used by sensors in a cluster to communicate the enhanced observations to its Cluster-Head and (iii) the ideal weight function used for the linear signal combination by each CH, so that the MSE is minimized under a network power restriction. In order to extricate the better performance, which is created by optimizing any set of these parameters, we often review three specific circumstances of the initial issue. In order to achieve an agreement on MSL that is similar to that of the Bayesian CRB, we identify three factors to measure the efficacy of each power allocation scheme. Combining the information gathered on the factors with Bayesian CRB with our complexity analysis, the system designer provides quantitative complexity versus MSE improvement compensations provided by different factors [11].

In 2020, Hossein Keshmiri' et al [12] have proposed a paper related to Wireless Sensor Networks (WSNs) distance coverage norms as well as the optimization strategies with respect to novel two phase optimization principles. In this paper [12], the authors illustrated such as Wireless Sensor Networks rely on a small energy supply as one of their most demanding energy consumption issues. Reporting and accessibility are also essential attribute of network service measurements. This paper explores the question of the linked goal coverage with a positive view of energy demand. A modern two phase proposed methodology offers full goal coverage and device access over the network life. The indicators are structured in the first stage of the algorithm into maximum pair wise cover-sets to use a complex re-integrated nonlinear regression model. Sets of other nodes which could not form an independent CS are assigned as subsets of hypothetical CHs as current CS, i.e., CHs are selected from their potential CH subsets for every active CS. In the second level, the algorithm triggers CSs one by one to collect information from the destination and forward it to the consumer in a hierarchical structure through a modified multi objective linear integer (MILP) model. In both ILP and MILP models, the branch-and-bound approach is used. Optimal solutions for the topology optimization are solved. The effectiveness of the routing protocol can be shown by several experiments in diverse circumstances compared to two of the most existing articles [12].

In 2020, Muhammad Adil'et al., [14] have proposed a paper related to Machine Access Code enabled Adhoc On-demand Distance Vector routing protocol based Wireless Sensor Network model authentication procedures. In this paper [14], the authors illustrated such as Wireless Sensor Networks are a freely organized infrastructure with different operating devices. These networks are used in numerous applications due to their immense features. For WSNs, real-time and reliable data must be obtained as essential decision-making is dependent on these readings in various application scenarios. Authentication of the operating devices is a challenge for the research community in WSNs because these networks are complex and self-organized. Moreover, a standardized glow encryption algorithm must be established due to the constraints focused design of these devices. This paper presents a lightweight transparent mutual authentication to overcome the WSN problem of black-hole attacks. Medium Access Control (Mac) address is employed in this scheme to record every node in WSNs with its closest CHs or BS module. The registration process is undertaken in an offline step to ensure that valid nodes and basic stations in an operating network are authentic. The proposed strategy addresses the problem of a black-hole attack as both the gate and neighboring nodes must be registered with the intrusion node which is not feasible. In addition, the hybrid data encryption system, ECIES integrated encryption standard and ECDDHP are used in enhancing the reliability, privacy and authenticity of the information obtained. The simulation results show remarkable effectiveness of the proposed framework in terms of minimum possible end-to-end communication and delays, maximum mean packet delivery ratio and performance in the presence of malicious node against known field techniques [14].

III. PROPOSED SYSTEM METHODOLOGIES

In this paper a new cluster based Wireless Sensor Network environment is initiated with a novel Energy Enhanced Routing Protocol (eeRP), in which it associates the Firefly algorithm for efficient Cluster Head (CH) election and the associated principles are more efficient to provide a flaw-free communication model[15]. The WSN environment highly depends on the energy efficiency, because the communication model is designed with wireless mobile sensor nodes, in which these sensor nodes are operated with respect to battery. The power efficiency of the sensor nodes are till the battery drains, so that a clustering pathway architecture is designed to eliminate such power affection issues. This paper introduces a new routing protocol with energy efficient cluster head election principles, which is called as eeRP and Firefly. These two algorithms are efficiently operated together to prove the proposed WSN model is highly efficient and the resulting section of the paper proves the effectiveness of the approach in graphical manner[16]. The following equation illustrates the principles to estimate the distance between nodes and the cluster head participant node and the CH participant node to the basestation as well[17].

$$\boldsymbol{D} \leftarrow \sum_{\boldsymbol{i=0}}^{\boldsymbol{nn}} \binom{j}{i} \Subset [(\boldsymbol{x^2} - \boldsymbol{x^1})\Omega \Subset (\boldsymbol{y^2} - \boldsymbol{y^1})]^{\boldsymbol{i}} \qquad \textit{(1)}$$

Where D indicates the distance measure between nodes, nn indicates the number of nodes, x and y indicates the overall WSN region[34-36]. The following algorithm, Algorithm-1 illustrates the Firefly algorithm Cluster-Head (CH) election principles with respect to the associated metrics of eeRP, in which the proposed model is executed with respect to the consideration of 3 different clusters with different specification of node quantities as well as the initiation of one source and three destination nodes.

A. Energy Enhanced Routing Protocol (eeRP)

In literature, there are several routing protocols available with different types of node configurations such as Adhoc on demand Distance Vector routing protocol (AODV), Dynamic Source Routing protocol (DSR) and so on. But all these classic protocols performance level is restricted in some frequencies[18-23]. This paper introduced a new routing protocol with enhanced routing metrics in association with cluster handling principles, in which it is called as Energy Enhanced Routing Protocol (eeRP). This approach of eeRP provides an intelligent routing metrics to perform inter and intra cluster communications[24-26]. In this methodology, the cluster regions are formed based on the principles of localization logic and the associated routing metrics of wireless sensor nodes[27-29]. The cluster head election process is handled by means of Firefly algorithm, in which it is briefly explained on the methodologies section with proper algorithm specifications[30-33]. This approach of Firefly ensures the selection of energy efficient cluster head selection process as well as the proposed routing metric guarantees the flaw-free communication between entities in an effective manner[21]. The following algorithm, Algorithm-2 illustrates the logic of proposed approach eeRP[22].

Algorithm-1 Firefly Cluster-Head Election Process

Input: *Traffic Mode, Number of Nodes, Source, Destination*

Output: *Cluster-Head Nodes with Index*

1. Define the objects for collecting the input parameter values such as tm, nn, source (sq1), destination (sq2, sq2d1, sq2d2). // Here number of destinations are considered as three.

2. Raise a For loop for initial node 0 to number of nodes (nn).

3. Acquire the position of defined clusters and the sensor nodes presented into the WSN environment.

4. Raise an inner For loop for distance metrics as similar as Step-2.

5. Estimate the distance based on the equation defined in methodologies section, equation (1).

6. Initiate an IF condition to check the node position is less than or equal to the defined threshold value between 12 and 16. // these values may vary due to the distance level consideration.

7. Check the distance level is greater than or equal to half of the entire WSN region circumstance.

8. If so, then fix that node as a Cluster Head for the respective region.

9. Otherwise, continue the loop until the next optimal node is elected as a cluster head.

10. Repeat the same process for all clusters specified into the WSN environment and find out the optimal CHs.

Algorithm-2: Energy Enhanced Routing Protocol

Input: *Number of Nodes, Source Node, Destination Nodes, Distance Ratio, CHs*.

Output: *Successful data transfer between entities.*

1. Define the input variables called nn, Src, Dest1, Dest2, Dest3, D and CH() array variable to acquire the input parameter values.

2. Initiate the Routing metrics as AdHoc and specify the variations such as routing channel and initial power.

3. Define the network link layer specifications as LL.

4. Specify the Machine Access Code as MAC-802.11 standard.

5. Initiate the Queue with the length of 500 to provide a successful cache for failure free communications.

6. Initiate the antenna model as Omni Antenna.

7. Specify the channel type as Wireless Communication Channel.

8. Associate the routing agents as TCP/UDP with the trace topologies to identify the route traces of the WSN communications.

9. Initiate the idle node power status ratio as 1.2J, receiving energy level as 2.3J and the transmission energy level as 1.6J.

10. Raise the FOR loop from node 0 to the last node of the WSN environment.

11. Initiate the communication with respect to the tracing agents and the route metrics defined.

12. Send the packets to the destination cluster nodes with respect to basestation as well as Tx and Rx efficiency specified in Step-9.

13. CH traces are properly reported into the associated traces.

14. Communication completed with Successful data transmission between entities.

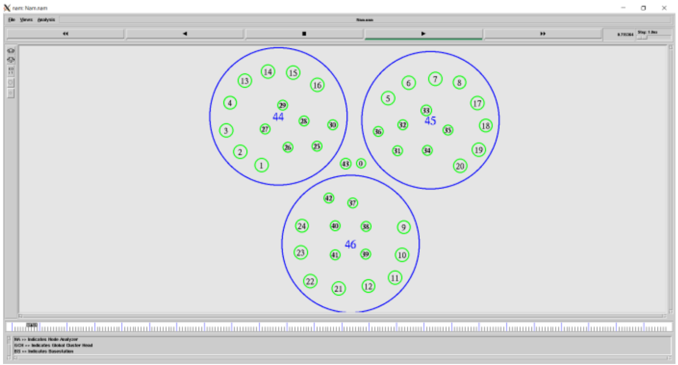
IV. RESULTS AND DISCUSSIONS

A novel routing protocol with energy efficiency association is implemented in this proposed approach of eeRP as well as the Firefly algorithm provides an efficiency to elect the proper Cluster head in an intelligent manner with respect to respective node position as well as an optimal distance between that node and the basestation. These strategies are integrated to provide an efficient routing between transmitter and receiver units based on the enhanced wireless communication model. The above mentioned two algorithms such as Algorithm-1 and 2 stated that in clear manner with process flow as well as the logic of proposed approach is implemented by using the powerful network simulation tool called Network-Simulator version 2 (NS2), in which it provides an efficient routing metrics with modified implementation logics of eeRP. In this section, the result and emulations are clearly visualized in graphical manner with practical implementation proofs based on proper accuracy ratios The following table, Table-1 illustrates the input parameters of the proposed approach.

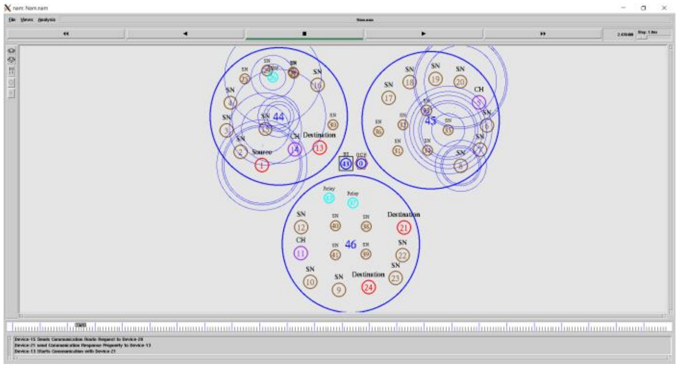
Table-1 Simulation Parameters

Input Parameter	Value
WSN Environment Size	1350X1100m
Number of Nodes	47
No. of Source Node	1
No. of Destination Nodes	3
Transmission Packet Size	2000 bits
Individual Node Strength	200J
Average Packet Transmission Speed	65bps
Node Mobility Range	500m
Traffic Estimation Metric	CBR
Interval	0.5ms

The following figure, Fig-1 (a) illustrates the wireless sensor network environment formation setup with number of nodes defined as per the table, Table-1 as well as the figure, Fig-1 (b) illustrates the proposed approach communication model. In which the Sensor Nodes (SN) are placed properly inside the cluster and to prove the efficiency of the proposed approach the logic of inter and intra cluster communication model is performed with respect to Firefly logic based Cluster Head (CH) election. The access point view is also specified into the network region with the mentioning of GCH and the basestation is marked as BS. The relay nodes are emulated to provide improved WSN coverage area as well as to improve the efficiency of cluster nodes with less expensive nature. The proposed approach eeRP provides dynamicity over cluster head election process by means of the Firefly logic as well as the cluster head selection procedure purely depends on the selection of source and destination nodes. Based on that logic of selecting the source and destination nodes the CH varies with respect to the localization principles. All these details are specified in the following figure with graphical illustrations in clear manner.



(a)



(b)

Fig.2 (a) WSN based Cluster Environment Formation and (b) Communication Process

The following figure, Fig-3 illustrates the throughput analysis of the proposed approach eeRP in comparison with the classic routing protocols such as AODV and DSR. In which the proposed algorithm efficiency is illustrated with the help of graphical results, x-axis indicates the number of nodes and the y-axis indicates the throughput efficiency ratio.

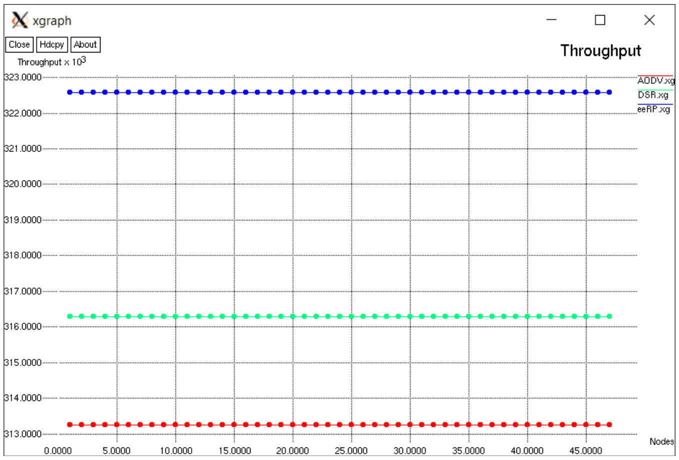


Fig.3 eeRP Throughput Analysis

The following figure, Fig-4 illustrates the end-to-end delay level analysis of the proposed approach eeRP in comparison with the traditional routing protocols such as AODV and DSR. In which the proposed algorithm eeRP's efficiency is illustrated with the help of graphical results, x-axis indicates the number of nodes and the y-axis indicates the delay ratio.

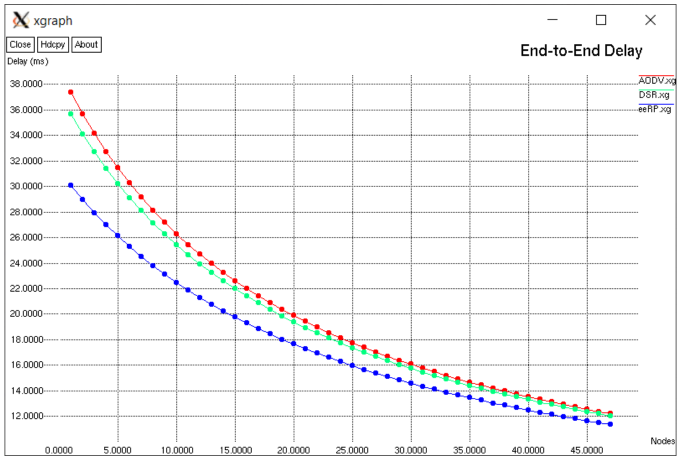


Fig.4 eeRP Delay Analysis

The following figure, Fig-5 illustrates the Path Selection Efficiency level analysis of the proposed approach eeRP in comparison with the traditional routing protocols such as AODV and DSR. In which the proposed algorithm eeRP's path selection efficiency ratio is illustrated with the help of graphical results, x-axis indicates the number of nodes and the y-axis indicates the path selection efficiency ratio.

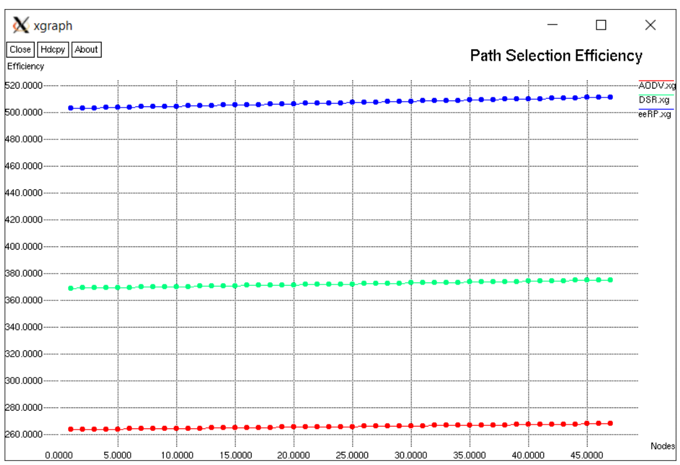


Fig.5 eeRP Path Selection Efficiency Analysis

The following figure, Fig-6 illustrates the Energy Efficiency level analysis of the proposed approach eeRP in comparison with the traditional routing protocols such as AODV and DSR. In which the proposed algorithm eeRP's path selection efficiency ratio is illustrated with the help of graphical results, x-axis indicates the number of nodes and the y-axis indicates the energy efficiency ratio.

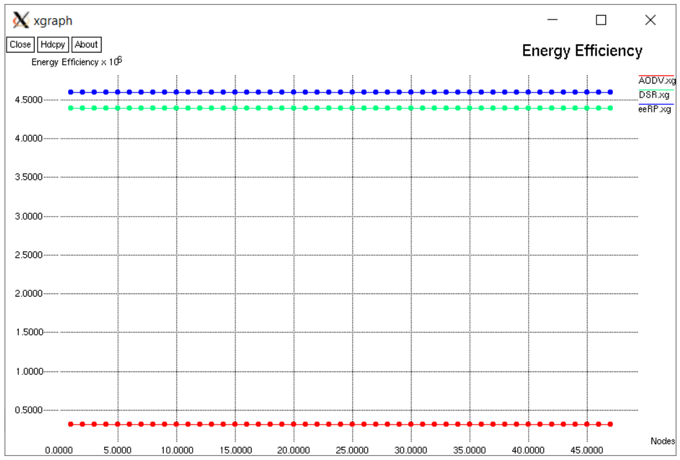


Fig.6 eeRP Energy Efficiency Analysis

V. CONCLUSION AND FUTURE SCOPE

In this paper, a new routing protocol called Energy Enhanced Routing Protocol (eeRP) is designed with proper route estimation metrics as well as the logic of Firefly algorithm is associated to handle the cluster based routing metrics. The Firefly algorithm provides efficiency to the proposed approach of eeRP to elect the efficient Cluster Head in association with distance and localization metrics of the Wireless Sensor Network environment. The proposed approach path selection metrics are effective in case of analyzing the route metrics with respect to the distance between cluster node and the cluster head as well as the estimation of distance between the cluster head and the basestation. The energy utilization is controlled by means of adapting the standard power ratio analysis principles, in which all the nodes are initialized with standard power ratio, so that the idle nodes can stay as it is without wasting the battery level. By using the proposed logic of eeRP based routing the throughput ratio and the energy efficiency level is improvised and the resulting section figures, Fig-3 and Fig-6 proves that in a graphical manner. The proposed approach of eeRP reduces the overall network delay as compared to the existing routing protocols such as DSR and AODV as well as the resulting section proves that in graphical manner over figure, Fig-4. The path selection efficiency is proved with the help of resulting section figure, Fig-5 in clear manner. For all the proposed approach of eeRP provides a good level communication metrics with proper channel efficiency and clustering procedures.

In future, the work can be extended by means of adding some cryptographic principles to add the security metrics to the data to be communicated over the Wireless Sensor Network environment. These features can assure the communication efficiency, route selection principles improvement as well as the security measures in good manner.

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