Neural Network based Energy Efficient Cluster Head Selection and Routing Protocol for MANET

[1]Karthikeyan Perumal
[1]Senior Software Consultant
[1]Intellisoft Technologies Inc., 1320 Greenway Drive STE 460, TX 75038, USA

Abstract - **Mobile Ad hoc Network (MANET) is comparatively a new paradigm of multi-hop wireless networking and has become popular. It is an essential part of the computing environment, consisting of infrastructure-less mobile networks. In MANET, each node communicates with other nodes directly or indirectly through intermediate nodes. The credit for the growth of ad-hoc network goes for its self-organizing and self-configuring properties. The nodes in the MANET are battery operated. Failure of some node's operation can greatly impede performance of the network and even affect the basic availability of the network, i.e., routing. Routing is an essential protocol in this field, because changes in network topology occur frequently. An efficient routing protocol is required to cope with highly fluid network conditions. Energy constraints are another big challenge in ad hoc wireless network design. These constraints in wireless network arise due to battery powered nodes which cannot be recharged. This becomes a bigger issue in mobile ad hoc networks because as each node is acting as both end system and a router at the same time, additional energy is required to forward packets. Hence this paper proposes Neural Network based Energy Efficient Cluster Head Selection and Routing Protocol (NECSRP)for MANET to optimize an energy efficient route between the source and the destination using neural network which is an emerging optimization algorithm. Finally, this paper concludes with comparing the proposed work with the various existing energy efficient routing protocols to ensure its effectiveness in improving the network life time by optimising the energy efficient route over the others. The simulation experiments are carried out using Glomosim simulator.**

keywords - **MANET, Network Life Time, Neural Network, NECSRP, Packet delivery ratio, Residual Energy**

I. INTRODUCTION

The mobile ad-hoc networking technology has stimulated substantial research activities in the past fifteen years. Many researchers were attracted to investigate this domain for further research and learning. Since MANETs are infrastructure-less, self-organizing, rapidly deployable wireless networks, they are highly suitable for applications involving special outdoor events, communications in regions with no wireless infrastructure, emergencies and natural disasters, and military operations, mine site operations, urgent business meetings and robot data acquisition. Ad hoc wireless networks inherit the traditional problems of wireless communications, such as bandwidth optimization, power control, and transmission quality enhancement. In addition, their mobility, multi-hop nature, and the lack of fixed infrastructure create a number of complexities and design constraints that are new to mobile ad hoc networks. Numerous problems and challenges exist in this field because of the frequent topology changes of unpredictable MANET. The mobility model plays a very important role in determining the protocol performance in mobile ad hoc Network. The mobility model [9] is designed to describe the movement pattern of MNs, and how their speeds and directions are changed over the time. Currently there are two types of mobility models used in the simulation study of MANET: 1.Traces base model and 2.Synthetic base model

The traces base model obtains deterministic data from the real system. This mobility model is still in its early stage of research, it is therefore not recommended to be used. Choosing suitable movement pattern depends on applications that use the model. The synthetic base model is the imaginative model that uses statistics. In the real world, nodes or objects have their target destination before they decide to move. However, the movement of each MN to its destination has a pattern that can be described by a statistical model that expresses the movement behavior in the real environment. This type of mobility model can be either Entity Mobility Model (EMM) or Group Mobility Model (GMM). In EMM, each node moves independently. Examples of this type of mobility model are Random Waypoint, Random Walk and Random Direction. For GMM, the movement of each MN depends on some other MNs in the group. Examples of GMM are Column Mobility Model and Reference Point Group Mobility Model. For EMM, the Random Waypoint mobility model [17] is widely used for the simulation study of MANET. The major problems of using this model are shape turn and sudden stop.

One very important property that an ad hoc wireless network should exhibit is organising and maintaining the network by itself. The major activities that an ad hoc wireless network required to perform for self-organisation are neighbour discovery, topology organisation and topology reorganisation. Self-organization [6] is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of a system. Moreover, the rules specifying interactions among the systems' components are executed using only local information, without reference to the global pattern. This definition of self-organization focuses on the emergence of patterns. Similar definitions can be found in the literature concerning well-studied methodologies in biological systems. The interaction of single components finally defines the behaviour of the global system. Applied to ad hoc networks, self-organization can be seen as the interactions between nodes in the network leading to globally visible effects, e.g. the transport of messages from a source node to a sink node.

Clustering mechanisms have been studied to enhance the performance in ad hoc networks while reducing the necessary amount of energy. The primary idea is to group nodes around a cluster head that is responsible for state maintenance and inter-cluster connectivity. Clustering is a crosscutting technology that can be used in nearly all layers of the protocol stack. Examples for efficient clustering algorithms are passive clustering which reduces the necessary overhead for maintaining the structure of the clusters, and on-demand clustering, which mitigates the need for permanent maintenance of clusters by creating them on-demand. The primary goal for employing clustering algorithms [13] is always to reduce the maintenance overhead as needed for global state methods. Obviously, this allows to reduce the energy consumption on a global level while reducing the possible performance as seen in global state mechanisms only a little. Nowadays Neural network plays a vital role in optimising the available resources.

Based on recent trends it was found that some issues such as routing, clustering, cluster head selection and energy management attracted much attention in the MANET. As the nodes in the MANET are battery operated, failure of some nodes operation can greatly impede performance of the network and even affect the basic availability of the network. Hence the paper is going to propose a Neural Network based Energy Efficient Cluster Head Selection and Routing Protocol (NECSRP)for MANET to optimise an energy efficient route between the source and the destination to improve the network lifetime of the MANET. The paper is organised in the way of detailing the literature survey in section II, proposed methodology in Section III, results and discussion in Section IV and conclusion and future work in Section V. The following section detail the various existing literature related to energy efficient routing for MANET and energy efficient cluster head selection techniques for MANET..

II. LITERATURE SURVEY

Routing [15] in a MANET depends on many factors including topology, selection of routers, and location of request initiator and specific underlying characteristics that could serve as a heuristic in finding the path quickly and efficiently. This makes the routing area perhaps the most active research area within the MANET domain. One of the popular MANET routing protocol categories is Topology based approach [8]. In topology based approach, it uses the knowledge of instantaneous connectivity of the network with emphasis on the state of the network links. In this approach the associated routing protocols are classified into three categories, based on the time at which the routes are discovered and updated. They are: Proactive Routing Protocol (Table Driven), Reactive Routing Protocol (On-Demand) and Hybrid Routing Protocol [17]. Proactive routing protocol [15] includes Destination-Sequenced Distance-Vector (DSDV) protocol, Wireless Routing Protocol (WRP), Optimized Link State Routing Protocol (OLSR) and Fisheye State Routing (FSR). Reactive routing protocol [1] includes Dynamic Source Routing (DSR) protocol, Ad hoc On-demand Distance Vector (AODV) protocol, Temporally Ordered Routing Algorithm (TORA). Hybrid protocols seek to combine the proactive and reactive approaches. An example of such a protocol is the Zone Routing Protocol (ZRP). On-demand routing is more efficient than proactive routing and most of the current work and modifications have been done in this type of routing for making it more and more better. The main idea behind this type of routing is to find a route between a source and destination whenever that route is needed whereas in proactive protocols by maintaining all routes without regarding its state of use. So in reactive protocols does not need to bother about the routes which are not being used currently. This type of routing is on demand. Discovering the route on demand avoids the cost of maintaining routes that are not being used and also controls the traffic of the network because it does not send excessive control messages which significantly create a large difference between proactive and reactive protocols. Because of the reason in the work, DSR on demand routing protocol is used to optimise the network life time of the MANET.

The Dynamic Source Routing (DSR) protocol [14],[17],[18] is reactive routing protocol for MANET. It uses source routing which means that the source must know the complete hop-by hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the source header. DSR is composed of two phases that work together to allow the route discovery and maintenance of source routes in the ad hoc network. Route discovery works by flooding the network with route request RREQ (also called query) packets. Each node receiving a request, rebroadcasts it, unless it is the destination or it has a route to the destination in its cache. Such a node replies to the request with a route reply RREP packet that is routed back to the original source. If any link on a source route is broken (detected by the failure of an attempted data transmission over a link, for example), route error RERR packet is generated. Route Maintenance is performed by each node that originates or forwards a data packet along a source route. Each such node is responsible for confirming that the packet has been received by the next hop along the source route given in the packet; the packet is retransmitted (up to a maximum number of attempts) until this confirmation of receipt is received.

MTPR (Minimum Total Transmission Power Routing) [12],[19] sets up the route that needs the lowest transmission power among possible routes. This scheme can be applied in the environment where transmission power adjustment is available. Because the required transmission power is proportional to the n-th power of the distance between nodes, this scheme prefers shorter links and has the tendency to select the route with more hops. However, MTPR has some problems. It turns out that the adaptation of transmission power can bring a new hidden terminal problem. The hidden terminal problem makes more collision, and it results in more energy consumption due to retransmission. Even if there is an algorithm proposed for the problem, it can not be implemented with the current technology. And, MTPR has a similar problem to min-hop routing in that it makes no efforts to use energy evenly among nodes.

MBCR (Minimum Battery Cost Routing) [12],[19] tries to use battery power evenly by using a cost function which is inversely proportional to residual battery power. The total cost for a route is defined as the sum of costs of the nodes that are the components of the route, and MBCR selects a route with the minimum total cost. This method seems to extend the network lifetime because it chooses the route composed of the nodes whose remaining battery power is high. However, because it considers only the total cost, the remaining energy level of an individual node may hardly be accounted for. That is, the route can include a node with little energy if the other nodes have a plenty of energy.

To prolong the lifetime of an individual node, MMBCR (Min-Max Battery Cost Routing) [12],[19] introduces a new path cost, which selects the route with the minimum path cost among possible routes. Because this metric takes into account the remaining energy level of individual nodes instead of the total energy, the energy of each node can be evenly used. However, this scheme can set up the route with an excessive hop count and then consume a lot of total transmission energy. CMMBCR (Conditional Max-Min Battery Capacity Routing)

In [5], [12],[19], author try to balance the total transmission power consumption and the individual node power consumption. This algorithm operates in two modes according to the residual battery power. If there are nodes that have more battery power than threshold power, it applies MTPR to the nodes. Otherwise, it mimics MMBCR. When battery power is plentiful, it minimizes the total energy consumption like MTPR, and in the other case it considers the nodes with lower energy like MMBCR. The performance of CMMBCR is heavily influenced by the threshold value. In a case where the threshold value is 0, it is identical to MTPR. As the threshold value grows by infinity, it is transformed into MMBCR. However it only depends on the threshold energy level only and it does not allocate energy utilization evenly throughout all nodes. It chooses a route whose bottleneck residual energy larger than a certain threshold. If there is more than one route satisfying this condition, then it selects the one with minimum total transmission power.

Energy Aware Routing with Efficient Clustering (EAREC) was proposed [2] for cluster-based communication to reduce network traffic and periodic sleep-awake time maintenance for the nodes to save energy. There will be one CH (cluster head) and at least one GW (gateway) in each cluster. All the nodes within a cluster are reachable from CH within one hop. The ordinary nodes will maintain two states Sleep & Idle. Jin Xin et al [10] proposed a hybrid routing algorithm for clustering. It is the combination of proactive policy and on-demand policy. Intra-cluster routing uses a proactive policy, whereas the inter-cluster routing is on-demand. In networks with low rates of mobility, clustering provides an infrastructure, which is more proactive. This enables more optimal routing by increasing the distribution of topology information when the rate of change is low. When mobility rates become higher, cluster size will diminish and reactive routing will dominate. The hybrid policy accompanies a better balance between routing overhead and quick routing. LEACH algorithm divides wireless sensor network into several clusters. The algorithm introduces a random clustering scheme for wireless sensor network [7]. It is a dynamic clustering routing method where nodes are selected as cluster head randomly based on a threshold value. Though, the energy consumption is distributed among all the sensor nodes, there is a possibility of none of the sensor node in the network selecting itself as a cluster head during some rounds. Hybrid EnergyEfficient Distributed clustering (HEED), introduced by [20], is a multi-hop WSN clustering algorithm which brings an energy-efficient clustering routing with explicit consideration of energy. Different from LEACH, in the manner of CH election, HEED does not select nodes as CHs randomly. The manner of cluster construction is performed based on the hybrid combination of two parameters. One parameter depends on the node's residual energy, and the other parameter is the intra-cluster communication cost. The use of tentative CHs that do not become final CHs leave some uncovered nodes. As per HEED implementation, these nodes are forced to become a CH and these forced CHs may be in range of other CHs or may not have any member associated with them. As a result, more CHs are generated than the expected number and this also accounts for unbalanced energy consumption in the network [4]. In the Cluster based energy efficient routing (CBEER) protocol, a virtual backbone is formed with the nodes having the highest energy in the domain to establish routes [18]. The modification of the DSR protocol results in reduction of unnecessary packets in the network due to the flooding of route error and route discovery packets. But the protocol did not consider any optimisation technique to optimise the cluster head.In the last thirty years, a great interest has been devoted to meta-heuristics. It is tried to point out some of the steps that have marked the history of meta-heuristics. Some of the meta-heuristic algorithms are Particle Swarm Optimisation (PSO), Artificial Bee Colony (ABC), Ant Colony Optimistion and etc. [22]. These meta-heuristic approaches may be suited for either local or global optimisation.

From the literature survey it is observed that the majority of the work concentrates on optimising enery efficient route without following any specific optimisation techniques to optimise the network life time through the optimisation of cluster heads. In the work network life time of the MANET is optimised through optimising the cluster head selecting using Neural Networks. The following section detail the proposed Neural Network Based Energy Efficient Cluster Head Selection And Routing Protocol (NECSRP).

III. PROPOSED NEURAL NETWORK BASED ENERGY EFFICIENT CLUSTER HEAD SELECTION AND ROUTING PROTOCOL (NECSRP)

The NECSRP protocol is designed to increase the life time of the MANET by selecting energy efficient cluster heads using neural networks. The selection of energy efficient cluster head not only increases the network life time but also improves the QoS parameters. The NECSRP protocol is designed to bring about energy aware route establishment in order to avoid the full drain of the energy from a node, which in the network forms a gateway to the other zones. The proposed protocol differs from the existing DSR protocol in the route discovery and energy aware route maintenance with higher percentage of reliable delivery of packets. In this protocol the cluster heads will be selected based on the Neural Networks. The need of clusters and cluster heads in MANET is discussed in the following.

A successful approach for dealing with the maintenance of mobile ad hoc networks is by partitioning the network into clusters. In this way the network becomes more manageable. It must be clear that a clustering technique is not a routing protocol. Clustering is a method which aggregates nodes into groups. These groups are contained by the network and they are known as clusters. A cluster [4] is basically a subset of nodes of the network that satisfies a certain properties. Clustering presents several advantages for the medium access layer and the network layer in MANET. The implementation of clustering schemes allows a better performance of the protocols for the Medium Access Control (MAC) layer by improving spatial reuse, throughput, scalability and power consumption. The purpose of a clustering algorithm is to produce and maintain a connected cluster. In most clustering techniques nodes are selected to play different roles according to a certain criteria.

In general, three types of nodes are defined. They are 1) Ordinary nodes, 2) Gateway nodes and 3) Cluster heads. Ordinary nodes are members of a cluster which do not have neighbors belonging to a different cluster. Gateway nodes are nodes in a non-cluster head state located at the periphery of a cluster. These types of nodes are called gateways because they are able to listen to transmissions from another node which is in a different cluster. To accomplish this, a gateway node must have at least one neighbor that is a member of another cluster.

The main task of a cluster head is to calculate the routes for long-distance messages and to forward inter-cluster packets. A packet from any source node is first directed to its cluster head. If the destination is located in the same cluster, the cluster head just forwards the packet to the destination node. If the destination node is located in a different cluster, the cluster head of the sending node routes the packet within the substructure of the network, to the cluster head of the destination node. Then, this cluster head forwards the packet to its final destiny.

Most clustering approaches for mobile ad hoc networks select a subset of nodes in order to form a network backbone that supports control functions. A set of the selected nodes are called cluster heads and each node in the network is associated with one. Cluster heads are connected with one another directly or through gateway nodes. The union of gateway nodes and cluster heads form a connected backbone. This connected backbone helps simplify functions such as channel access, bandwidth allocation, routing power control and virtual circuit support. Since cluster heads must perform extra work with respect to ordinary nodes they can easily become a single point of failure within a cluster. For this reason, the cluster head selection process should consider for the cluster head role, those nodes with a higher degree of relative stability.

In summary, choosing an optimal number of cluster heads which will yield high throughput but incur as low latency as possible, is still an important problem. More cluster heads result extra number of hops for a packet when it gets routed from the source to the destination, since the packet has to go via larger number of cluster heads. Thus this solution leads to higher latency, more power consumption [3] and more information processing per node. On the other hand, to maximize the resource utilization, choosing the minimum number of cluster heads to cover the whole geographical area over which the nodes are distributed is important. The whole area can be split up into zones, the size of which can be determined by the transmission range of the nodes. This can put a lower bound on the number of cluster heads required. The energy efficient cluster head selection procedure is discussed in the following.

Energy Efficient Cluster Head Selection using Neural Networks

Once the whole region is divided into different clusters, the next phase is to choose the cluster head among the participating nodes to balance energy consumption. Many CHs selection mechanism are proposed over the years out of which many proposals favour uniformly distributed clusters with stable average cluster sizes. In this section it was proposed a method to choose CH using Neural Networks [11].

A Neural Network (NN) is a large system containing parallel or distributed processing components called neurons connected in a graph topology. These neurons are connected through weighted connections called synapses. Weight vectors (synapses) connect the network input layer to output layer. Indeed, the knowledge of NN (Jaisinh 2012) is stored on weights of its connections and it doesn't need to any data storage. In other words, Artificial Neural Networks are arithmetic algorithms which are able to learn complicated mappings between input and output according to supervised training or they can classify input data in an unsupervised manner.

A five layered feed forward neural network is used to predict the final energy level of the individual nodes in the cluster. The input patterns belong to one wireless node and by using them as the inputs of the neural network can predict the energy level of the mobile node at the last of network lifetime. These patterns may be in the form of features coded from node's distance from sink, node's distance from the neighboring border, node's number of neighbors, the number of neighbors which initially route their data through this node. After deploying nodes, the base station receives nodes positions and neighbor's information, thus it can easily calculate these patterns for each node and the neural network can be able to predict their final energy level. A well-trained neural network would be able to receive each node's features as the inputs and predict its final energy level. Thus, the neural network is used to increase the life time of the network. The Fig.1 shows the cluster head selection using ANN.

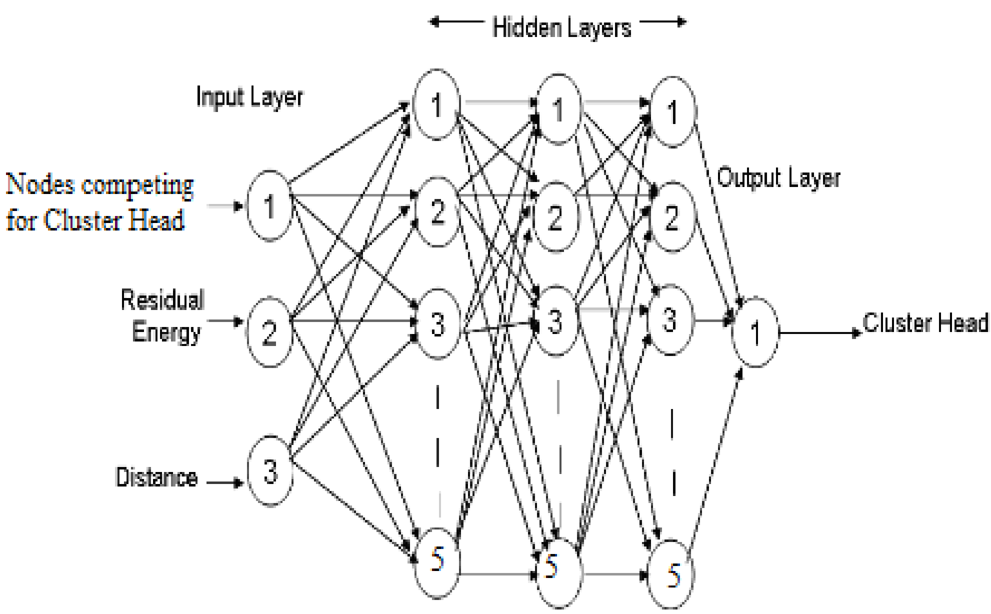

Figure 1 Cluster head selection using ANN

Selecting Group Heads amongst all the nodes is also energy conserving scheme. Each node collects data which are typically associated with other nodes in its neighborhood, and then the associated data is sent to the Base Station through Group Head for evaluating the tasks more efficiently. Assuming the periodic sensing of same period for all the nodes and Group Head is selected. Inside each fixed group of nodes, a node is periodically elected to act as Group Head through which communication to/from Group nodes takes place. The set of Group Head nodes can be selected on the basis of the routing cost metric explored by the Eq. 1:

$$R_{cm} = e/a_r\{ e_t(N_s,N_d)+e_r (N_s,N_d)\} \quad (1)$$

Where,

e - Energy associated with the delivery ratio of packet, delivered correctly from source node N_s to the destination node N_d

$e_t(N_s,N_d)$ - Energy required to transmit from Ns to Nd and

$e_r (N_s,N_d)$- Energy received at Nd,

e_r - The range area of the network.

The cluster head selection process is initialized with giving the set of nodes competing for cluster head as the input vector to the input layer of the ANN feed forward network. The hidden layers calculates the routing cost metric using Eq. 1 and choose the cluster head is by the nodes having smaller energy associated with the PDR. The weight vectors in the hidden layers updating the weights based on the smaller distance with the nodes and the CHs. This process will be repeated and the ANN will be trained to choose the CHs using minimal energy to deliver the packets to the destination. The route discovery and route maintenance procedures are similar to the DSR protocol.

The following section will analyse the results of the proposed NECSRP technique with the existing routing protocols.

IV. RESULT AND ANALYSIS

The proposed and the existing mobile ad hoc network routing protocols are simulated within the GloMoSim [21] library. The GloMoSim library is a scalable simulation environment for wireless network systems using the parallel discrete-event simulation capability provided by PARSEC. This section compares the proposed NECSRP with the basic on-demand routing DSR and existing CBEER protocols.

The various parameters that were estimated during the simulation are as follows:

Packet Delivery Ratio: It is defined as the ratio of number of packets received to that of the number of packets sent. It is given in Eq. 2.

$$\text{Packet Delivery Ratio} = \frac{Total\ data\ packets\ received}{Total\ data\ packets\ sent} \quad (2)$$

Control overhead: It is defined as the sum of number of route requests, route replies & route errors as in Eq.3.

$$\text{Control overhead} = \text{RREQ+RREP+RERR in packets} \quad (3)$$

Average Residual Energy : It is taken as the average of the remaining energy levels of all the nodes in the network and It is given in Eq. 4.

$$\text{Average residual energy} = \sum \frac{remaining\ energy\ of\ individual\ nodes}{total\ number\ of\ nodes} \quad (4)$$

End to End Delay: It is the overall average delay experienced by a packet from the source to that of the destination. This is the average time involved in delivery of data packets from the source node to the destination node. To compute the average end-to-end delay, add every delay for each successful data packet delivery and divide that sum by the number of successfully received data packets as given in Eq. 5.

$$\text{Average end to end delay} = \sum \frac{Time\ received - Time\ sent}{Total\ data\ packet\ received} \quad (5)$$

These metrics were estimated by varying the following parameters: Speed (m/s) and Number of nodes

The simulation input parameters apart from varying values used for study and analysis are in the following given Table 1 (from GloMoSim simulator, config.in file, app.con file):

Table 1 Parameters used for simulation

PARAMETER	VALUE
Simulation-Time	15m
Seed	1
Node-Placement	Uniform
Mobility	Random-Waypoint
Mobility-Wp-Min-Speed	0
Radio-Initial-Power-Level	4000
Radio-Frequency	2.4e9
Radio-Bandwidth	2000000
Mac-Protocol	802.11
Promiscuous-Mode	Yes
Network-Protocol	Ip
Routing Protocol	Dsr

Pause Time	50s
Terrain Dimension	1000x1000 Square Meter

The performance comparison of the proposed NECSRP with the existing DSR and CBEER protocols in respect of varying the node density of the network and average residual energy is shown in Fig. 2. The density of the nodes is varied by varying the number of nodes in the network. The node density is varied from 10 to 100 with the following constant parameters in the simulation.Speed of the node is 5 m/s, pause time is 50s and the terrain dimension is 1000 m x 1000 m.

When the density of the node increased from 10 to 100 nodes the average remaining energy of the nodes also increased because more number of intermediate nodes available to transmit the packets in the network. It is thus inferred that the proposed NECSRP would increase the network life time by increasing the average remaining energy 34.12 % and 18.87 % respectively over the existing DSR and CBEER protocols.

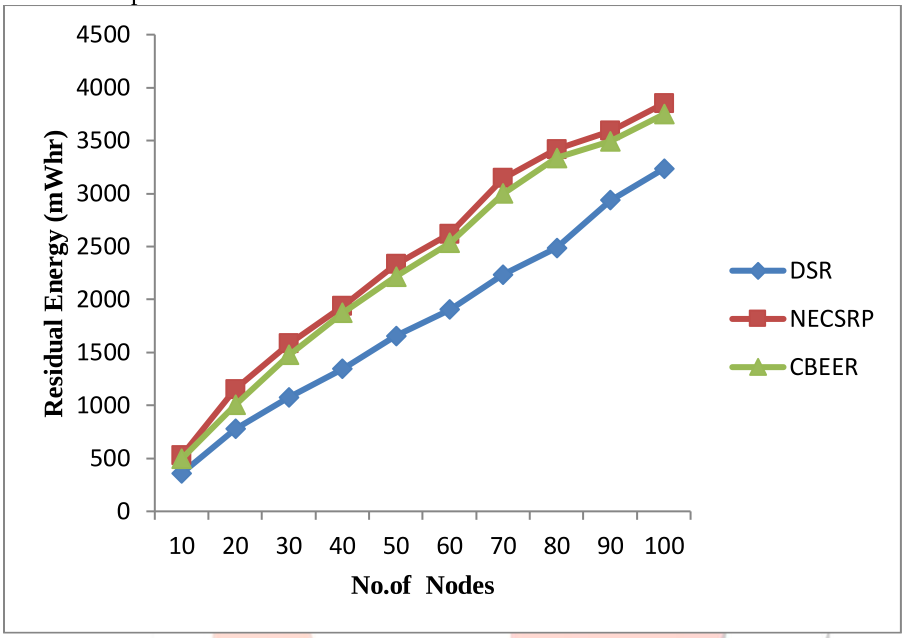

Figure 2. No.of Nodes Vs Residual Energy

Figure 3 shows the graph between varying number of nodes and the end to end delay in ms for the proposed NECSRP compared with the existing DSR and CBEER protocols. When the density of the node increases from 10 to 100 nodes the average end to end delay of the end nodes also increases because of the time consumed for route discovery and the increasing number of packets in the buffer. The statistics shows that the NECSRP protocol reduces the average end to end delay by 38.36 % and 26.43 % over the DSR and CBEER protocols respectively.

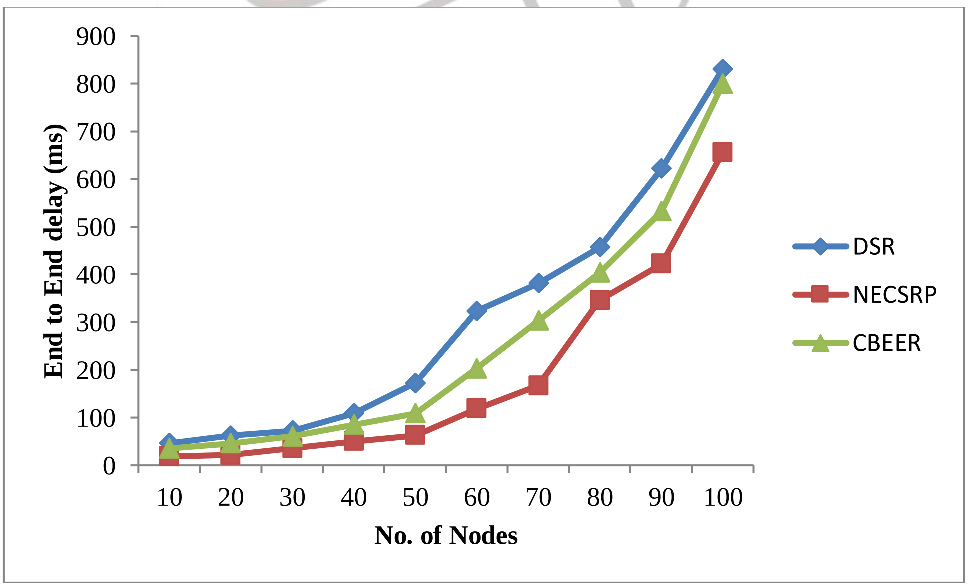

Figure 3. No.of Nodes Vs End to End Delay

Figure 4 shows the graph between varying number of nodes and the packet delivery ratio for proposed NECSRP and the existing DSR protocol. When the density of the node increases from 10 to 100 nodes the average packet delivery ratio increases because of the more number of routes available to broadcast the packets from the source node to the destination node. The simulation results shows that the NECSRP increases the PDR by 28.24 % over the existing DSR protocol.

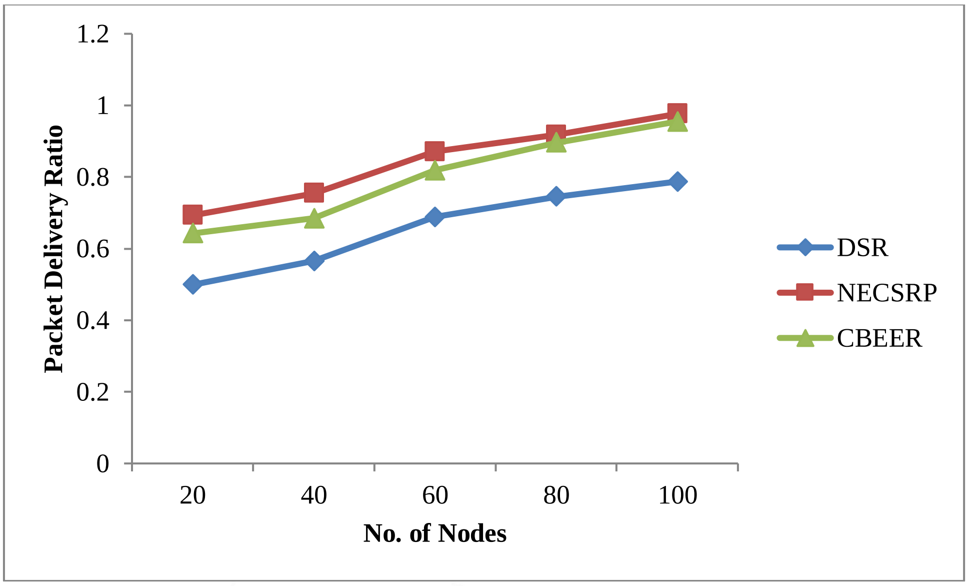

Figure 4. No.of Nodes Vs Packet Delivery Ratio

Figure 5 shows the graph between the varying speed of nodes in m/s and the average residual energy in mWhr for the proposed NECSRP with the existing DSR and CBEER protocols. When the speed increases from 2 to 10 m/s, the average residual energy of the nodes decreases because the frequent topology change causes more overhead in route discovery which consumes more energy of the mobile nodes. The NECSRP protocol increases the network lifetime by increasing the average residual energy by 33.34 % over the DSR protocol and 4.19 % over the CBEER protocol.

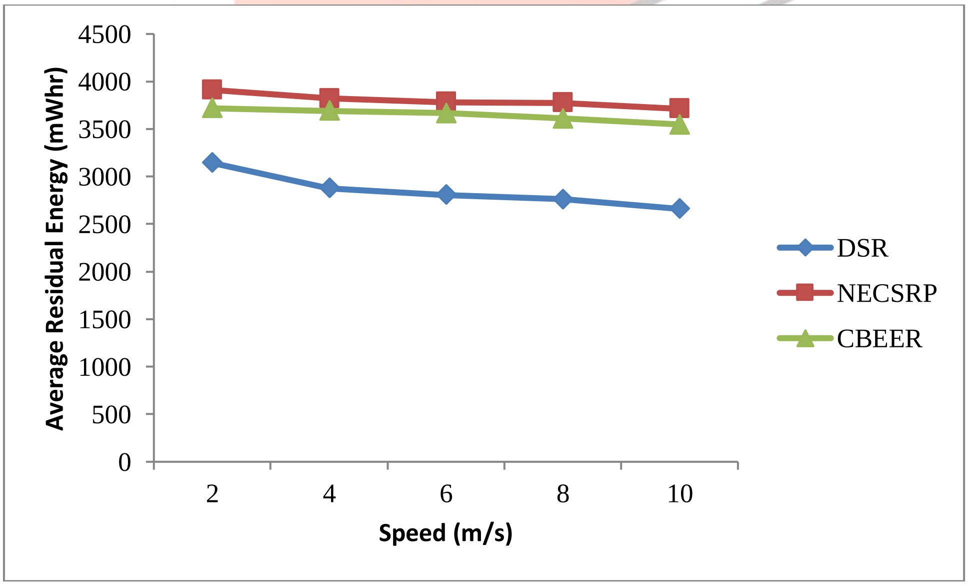

Figure 5. Speed Vs Average Residual Energy

Figure 6 shows the graph between varying speed of the nodes in m/s and the control overhead in packets for the proposed NECSRP comparing with DSR and CBEER protocols. If the speed of MNs increases, the frequent topology change causes more overhead in route discovery. The statistics shows that the NECSRP protocol reduces the control overhead by 54.98 % over the DSR protocol.

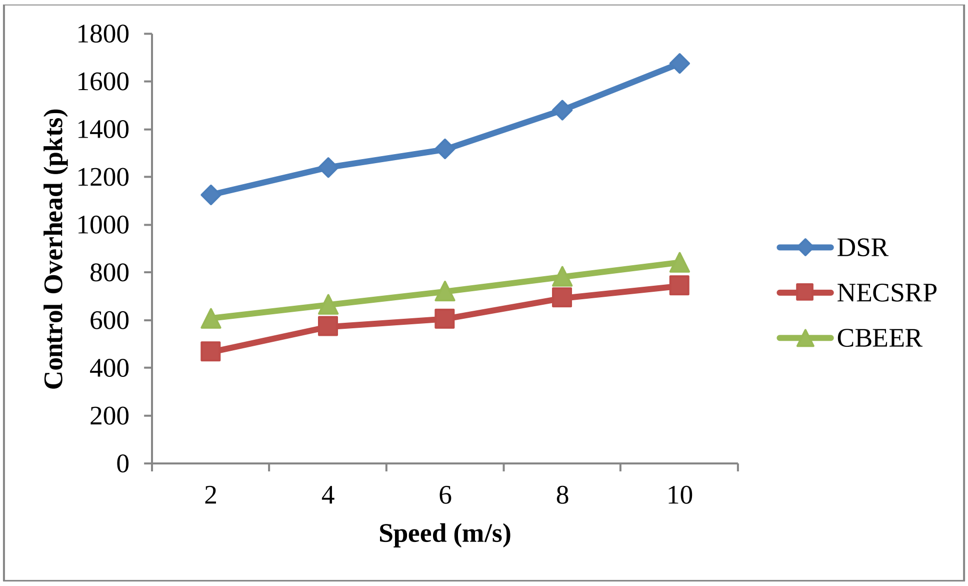

Figure 6. Speed Vs Control Overhead

V. CONCLUSION AND FUTURE WORK

The paper proposed Neural Network based Energy Efficient Cluster Head Selection and Routing Protocol (NECSRP) for MANET to optimise an energy efficient route between the source and the destination using neural network which is an emerging optimisation algorithm. A five layered feed forward neural network is used to predict the final energy level of the individual nodes in the cluster. Node's competing for cluster head, residual energy and node's distance from the neighboring border are applied as input to the ANN to optimise the cluster head. From the results it is inferred that the proposed NECSRP improves thenetwork life time of the MANET. The work may be further extended by introducing malicious nodes in the network. Hence security constraints may be introduced in the proposed protocol and study can be conducted on their consistence. The proposed protocol is implemented using the DSR protocol only. These may be extended to other proactive and hybrid routing protocols and their performance may be studied.

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