An Energy Efficient Clustering based Distributed Load Balancing Technique for Mobile Adhoc Networks

M.A.MariaParimala, S.Saravanan

Abstract: ***In a mobile adhoc network (MANET), energy efficiency and mobility prediction are the two main challenging design issues due to the mobile nature of the nodes in any direction with limited battery lifetime, thus leads to adequate topology modifications. These two issues are mainly considered to maximize the lifetime of MANET. Load-balancing and reliable data transmission among the mobile nodes is mandatory to increase the network lifetime. To achieve this, clustering techniques can be employed to minimize the topology size and to aggregate the details related to the topology. In this paper, we introduce a new clustering based distributed load balancing (D-CALB) algorithm to maximize energy efficiency and network lifetime. Furthermore, a fault tolerant feature is included in the D-CALB algorithm, which maintains a secondary CH as a backup node in case of the failure of the present CH. The presented ZXCD- CALB algorithm has undergone an extensive set of experimentation under a varying number of nodes and speed. The detailed investigation of the experimental results verified the superior nature of the presented D-CALB algorithm over compared ones under several measures.***

Index Terms: ***Clustering, Fault tolerance, Load balancing, MANET.***

I. INTRODUCTION

A mobile ad hoc network (MANET) contains a set of independent mobile nodes which are linked to one another by the use of multihop wireless connections [1] as shown in Fig. 1. It does not require any standard architecture and holds devices on the fly which undergone deployment for particular applications. These networks are mainly applicable in a scenario which is hard or expensive to construct infrastructure like disaster relief operations, border services, and data transmission among the vehicles in vehicular ad hoc networks (VANET) as shown in Fig. 2. MANET enables the user to transmit data with no fixed infrastructure. A temporary network without any wired connections, communication infrastructure and centralized control is needed. While forwarding the data packets, each node plays as a host and router in MANET. In addition, the nodes can move in a random manner. The interoperating ability among the nodes and its self-organizing ability in order to adapt to the dynamic circumstances are the significant factors of networking by large scale [2].

The designing of protocols in MANET is the main problem in the aspect of energy efficiency. At the network layer, numerous researchers modeled various routing protocols; however, they have taken into consideration the metrics like residual battery capacity, self-organization and transmission power when routing the data packets towards the destination [3].

The lifetime of the network is based on energy resource management. It is advantageous to utilize low power during the process of routing than saving the node battery power [4]. In MANET, for modeling energy efficient routing protocols, many researches had been carried out [5]. There are two ways to minimize energy, namely inactive communication energy and powerful communication energy. To reduce active communication energy, load balancing and transmission power control are employed. To reduce the inactive communication energy, the sleep down mode is employed. In MANET, the above mentioned works concentrate on the problem of energy-efficient communication without network coding.

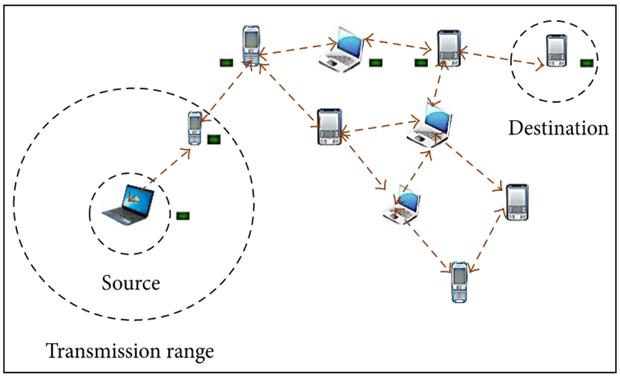

Fig. 1. MANET architecture

Because of the absence of central authority and self-configuring nature, network management is complex. Additionally, in the last decades, scalability is the main problem and it gains more attention in the communication research world.

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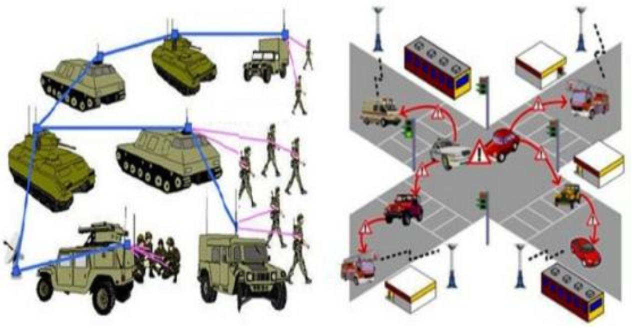

Fig. 2. MANET applications

Various MANET problems are resolved using clustering, which is a significant method and offers enhanced lifetime as well as network scalability. In every cluster, the nodes are separated by virtual groups that act as a local coordinator. Through cluster heads, the communication is carried out from source towards a destination, which is in the transmission range of one another.

The network management can be highly improved by the use of clustering. The use of clustering process enables the selection of CHs and the remaining nodes are defined as cluster members as shown in Fig. 3. The members simply sense and forward the data to CHs. The CHs acquire the additional work load of intercluster and intracluster transmission. It offers earlier energy depletion and CH death that segments the network ultimately and minimizes the lifetime of the network. Therefore, in a clustering method, the node mobility is the main reason for link failure, mainly in the circumstances, while the selected CH is highly mobile when compared with the other node.

Due to mobility, a formulated cluster will be dissolved frequently and need a different intercluster path setup towards destination from the source. Otherwise, in worse circumstance, there exists a requirement of reclustering. Because of the CH movement, the data transmission reliability gets decreased and routing overhead gets increased results in reduction of network lifetime.

To improve the lifetime of the network in MANET, modeling an effective clustering technique with reduced overhead could be a superior method.

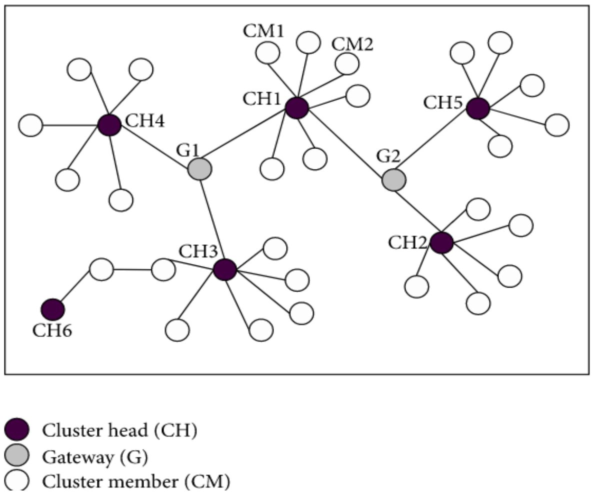

Fig. 3. An illustration of clusters in MANET

In this paper, we introduce a new clustering based distributed load balancing (D-CALB) algorithm to maximize energy efficiency and network lifetime. The D-CALB algorithm efficiently selects the proper cluster heads (CH) and also effectively balances the load among the mobile nodes present in the network.

The presented D-CALB algorithm offers the computation of distance among the mobile nodes to make sure they are in the transmission range of one another. In addition, the nature of the distributed clustering technique helps to reduce the unwanted network overhead by exchanging control packets among the nodes in MANET.

Furthermore, a fault tolerant feature is included in the D-CALB algorithm, which maintains a secondary CH as a backup node in case of the failure of the present CH.

The presented D-CALB algorithm has undergone an extensive set of experimentation under a varying number of nodes and speed. The detailed investigation of the experimental results verified the superior nature of the presented D-CALB algorithm over compared ones under several measures.

The remaining part of the paper is organized as follows. Section 2 outlines the current works relevant to the presented work. Section 3 presents the D-CALB algorithm and simulated results are discussed in Section 4. Finally, the paper has a conclusion with some highlights in section 5.

II. RELATED WORK

Various routing protocols and clustering approaches have been reviewed here, which are modeled primarily for MANET [5]. To tackle the problems of mobile nodes battery dependency and mobility limitations, diverse approaches has been projected. A clustering techniques classification of MANET is presented in [5], which reduces the node energy utilization and enhances the battery usage that is the main problem of wireless ad hoc networks. With lower overhead, there exist single metric CH selection techniques without considering the other nodes qualifications to be a CH.

For MANETs, a new weight based clustering algorithm (WCA) is projected in [6]. Higher than one parameter is merged that is mobility, time and connectivity degree until a node plays as cluster head and for selecting cluster heads, the distance sum towards node's neighbors is calculated. This technique is the foundation for entire approaches of weight based clustering, which assumes CH selection parameters. But, there exist some particular factors that minimize the WCA efficiency. For MANET, distributed weighted clustering algorithm (DWCA) is projected in [7] that restrains cluster reconfiguration and configuration over CHs by means of power requirement. When determining CHs, there are no parameters that define the stability of the node.

A novel improved weighted clustering technique version has been projected in [8] known as Enhancement on Weighted Clustering Algorithm(EWCA). Transmission range, battery energy, transmission power and mobility are the parameters employed for CH selection. Through preventing the dynamic changes in CH, the average cluster formation instance count is minimized. In MANET, EWCA handles the load balancing and enhances cluster stability.

Additionally, with bio-inspired computing and evolutionary proliferation in various study domains, it is a superior method of partitioning the optimized network and establishing the route in wireless networks.

At present times, numerous stochastic and deterministic techniques had been built for those networks [9-15]. The techniques that depend on gradient method are deterministic as they are hard computing depending on a particular geometrical formula which cannot be modified. Motivated through the living creatures, the stochastic techniques are the problem of multimodal in numerous directions.

In ad hoc networks, an overview of various bio-inspired populationbased metaheuristic techniques has been presented in [9]. For reduced loaded CH selection and node affiliation towards it, the researchers in [10] have presented a breadth-first search tree (BFS) based clustering technique. The technique of Genetic Algorithm (GA) optimization had been modeled in [11] that imitate the Darwinian theory of survival of the fittest. For WSN, the researchers had modeled a GA depending on load balanced clustering in [12] where the higher loads over gateway nodes are reduced and affiliated nodes produce load balanced clusters.

In MANET, an adaptive cluster formation is projected [13] by employing particle swarm optimization (A-PSO). For the selection of CH, various parameters are used by the researchers that create stable clusters. But, with effectiveness, the node mobility is not managed. During the clustering procedure, PSO is employed to search for effective CHs without aiming over optimization. Depending on the technique of particle swarm optimization, energy efficient routing protocol has been modeled for MANET in [14]. The MANET routing problem is formed as an optimization issue and produced as different fitness function depending on route energy level and length of the route. For MANET, for optimizing TORA routing protocol, they employed binary PSO.

An energy efficient routing and clustering approach is built in [15] where they assumed both load balancing and energy efficiency when modeling nonlinear and linear programming issues depending on PSO. By employing comprehensive learning particle swarm optimization (CLPSO), the researchers have projected clustering in MANET in [16]. The considered parameters for selection of CH are similar as of WCA without considering the motion of nodes direction while determining the CH stability.

III. PROPOSED WORK

The overall process of the presented D-CALB algorithm is given here. Once the mobile nodes are deployed in the exciting region, the initialization process will take place to gather data about its neighboring nodes. Since the nodes are mobile in nature, it is essential to keep track of the position or distance of the neighboring nodes for reliable and efficient data transmission. The presented D-CALB model operates on two stages: clustering construction stage and faults tolerant stage. In the clustering process, the weight function employed for CH selection depends commonly over nodes residual energy in MANET context.

However, low memory and processing ability might also tend to the saturation of CHs. As the saturated CH doesnot do intra-cluster management, data aggregation and inter-cluster transmissions,the nonattached mobile nodes does not merge with it.So,the election of CH depends on memory, processing abilities and residual energy of mobile nodes in this study. The selection procedure is carried out in a distributed way. A set of four sub-processes are comprised in the projected D-CALB algorithm as discussed below.

A. Initialization phase

A data vector Vector-MSG(e_i, m_i, c_i) is transmitted by every mobile node in the primary phase towards the neighbors set Ni and derives a data vector provided through every neighbor j. The vector of data comprises data relative to memory m_i, processing c_i and energy e_i of node abilities. The node i estimates the mark M_{ij} and transmits Mark-MSG (M_{ij}) for every neighbor j. The mark M_{ij} is computed as

$$e_k + m_j/\sum_{k\in c_k} m_k + e_j/\sum_{k\in c_k} c_k \quad (1)$$
$$M_{ij} = e_j/\sum_{k\in c_k}$$

The node i estimate the eligibility weight W_i and transmits Weight-MSG(EW_i)to the neighbors set while mark relative to neighbor's sets are derived and expressed as

$$W_i = \sum_{k\in N_i} M_{k,i} \quad (2)$$

B. Cluster-Heads Self-Designation

The election of CH is done in the iterative procedure order in this process. The node *i* constructs the eligibility weights vector after getting eligible weights are derived from entire neighbors. The node *i* might decide the nodes comprising higher eligible weights accordingly. In addition, self-election may also be done.

C. Clusters Formation

In this phase, load factor LF_iwill be estimated for each node chosen in the previous process. Then, deg_i represents the collection of neighboring nodes and weight W_i:

$$LF_i = \frac{EW_i}{deg_i} \quad (3)$$

To the entire neighbors set, the CH transmits the CH-DECLARE-MESSAGE(Cluster_ID) which is a self-designation message. To the newly selected CH, the non-attached mobile node gets a self-designation message and merged the CH with high LF. It transmits Join-MSG (i) as join message when node$j$ gives its determination.

D. Control Packet Generation

It is difficult to maintain the clusters in the case of the highly mobile environment. The mobile nodes tend to move around all directions irrespective of its status of CH or cluster member. The proposed work generates a new control packet called CMIDD, which indicates the cluster member distance vector. The introduced control message packet includes relevant two fields, namely id and its position. This control packet will be generated and circulated within a cluster. No control packets will be transmitted outside the cluster. In each and every cluster, the CHs and cluster members exchange CMDD packet for making sure whether the nodes are not moved out of the communication range of one another. In contrast to the traditional way of transmitting control packets to the entire network, the presented D-CALB algorithm sends control packet only to the nodes lie within the cluster. It leads to a significant reduction in the control overhead.Table 1 describes the CMIDD control packet.

Table 1:Cluster Member Distance Awareness Packet(CMIDD) Format

0 8 16 24 31

Type	Reserved	Identification Number	Hop count
ClusterHead(CH)-Distance -Req-id			
Time in Seconds		ClusterMember-Position(x_{CM},y_{CM})	
ClusterHead-IP Address			
ClusterHead-Sequence Number			
ClusterMember-IP Address			
ClusterMember-Sequence Number			

E. Fault Tolerance

The D-CALB algorithm provides the additional functionality of fault tolerance by providing a secondary CH for each cluster. The secondary or standby CH acts as a backup CH in case of CH failure, or CH dies because of energy depletion. Using the presented D-CALB algorithm, the loads undergo uniform distribution and attains maximum lifetime. For achieving fault tolerant characteristics in the network, the chosen secondary CHs is employed for replacing the current CHs in case of CH failure or energy exhaustion. This secondary CH is selected using the weight criteria W_i. The node with second highest W_i will be selected as a backup CH.

The pseudo-code of D-CALB algorithm is as follows:

Algorithm 1 D-CALB Algorithm

Input : S: Set of mobile nodes in the network.
N:Set of neighbor nodes
Output: C: Set of Clusters

//Cluster Initialization
Begin
For each node i €S do
Send DataVect-MSG(e_i,m_i,c_i);
For each node j € N_i do
Receive DataVect-MSG(e_i,m_i,c_i);
End For
End For
For each node i € S do
Calculate MarkM_{ij} for each neighbor j of node i ;
Send Mark-Message(M_{ij});
For each node j € N_i do
Receive Mark-Message(M_{ij});
End For
End For
For each node i € S do
Calculate Eligibility weight EW_i;
Send WGH-Message(EW_i);
For each node j € N_i do
Receive WGH-Message(EW_i);
End For
End For

//Cluster Head Selection
For each node i € S do
while (j <= N_i) do
If (EW_i>EW_j) then
j←j+1
else
break while loop
End if
end while
if (j > N_i) then
The node i becomes CH.
CH_EW=EW_i
End if
End For
Send CH-DECLARE-MESSAGE(Cluster_ID)
For each node j € N_i do
Receive CH-DECLARE-MESSAGE(Cluster_ID)
End for
Cluster member sends Join_MSG(member-ID) to CH.

//Backup Cluster Head Selection
For each node i € S do
while (j <= N_i) do
If((EW_i>EW_j) and (EW_i< CH-EW))then
j←j+1
else
break while loop
end if
end while
if (j > N_i) then
The node i becomes Backup-CH.
End if
End For
Send BACKUP CH-DECLARE-MESSAGE
For each node j € N_i do
Receive BACKUP CH-DECLARE-MESSAGE
End for

//Control packet generation
Each Cluster member within timestamp
SendCMIDD_MSG(Cluster_ID, Member_ID,Distance)
If (CH=Cluster_ID)
Receive CMIDD_MSG (Cluster_ID,Member_ID,Distance)
End if

End

IV. PERFORMANCE EVALUATION

The performance of proposed D-CALB algorithm is evaluated by the different network scenario with NS2 simulation tool.The mobile nodes are randomly deployed in the network with 1500m x 3000m network area.The constant bit rate traffic source is used for entire stimulation scenarios. The performance of the proposed D-CALB algorithm is experimented and a comparison is made with the existing CALB algorithm. In addition, the analysis of the results takes place in two ways namely varying number of nodes and varying speed.The analysis is made under several measures such as average delay, energy consumption, overhead, packet delivery ratio (PDR) and throughput.The simulation scenario is recorded in Table 2.

Table 2:Simulation Scenario

Simulation Parameters	Values
Network Size	1500m x 3000m
Number of Nodes	25
Simulation Time	1500s
Mobility Model	Random way point
Channel Bandwidth	2Mbps
Transmission Range	200m
Initial Energy	100 Joules
Node Speed	2.5,5,7.5
Transmission Power	0.175 Joules
Receive Power	0175 Joules

A. Results Analysis Under A Varying Number Of Nodes

Figure 4 shows the analysis of the results of the proposed D-CALB under a varying number of nodes from 5 to 30 in terms of PDR. The figure clearly indicates that the maximum value of PDR is achieved by D-CALB compared to CALB. In addition, CALB shows poor results with minimum PDR compared to D-CALB. Under the presence of 5 nodes, the CALB tries to manage well by attaining the PDR of 91.5%, but it fails to outperform the projected D-CALB which attains 95.9% as PDR. For instance, under 15 number of nodes, the D-CALB achieves a maximum PDR of approximately 85.2% whereas the existing CALB attains a minimum PDR value of 84.1%. In addition, under 30 nodes, D-CALB obtains higher PDR of 77%. But, the CALB show lower PDR of 74.4%. It is absolute that the presented D-CALB is efficient for a varying number of nodes in terms of PDR.

Fig. 5 shows the result analysis of different routing protocols in terms of throughput. From the figure, it is evident that the CALB shows inferior results over the proposed D-CALB method. The projected D-CALB exhibits maximum throughput over the compared CALB method in a significant way under a varying number of nodes. For instance, under the presence of 5 nodes, the D-CALB achieves a maximum throughput of approximately 49Kbps, whereas the existing CALB attains minimum throughput values of 46.5Kbps. In addition, under 15 nodes, D-CALB obtains higher throughput of 41.5Kbps. But, the CALB show lower throughput of 38Kbps. Similarly, under the circumstance of 30 nodes, a maximum of 31 Kbps throughput is obtained by D-CALB. In the same case, the existing CALB attains 29.6Kbps of throughput. Therefore, it is clear that the superior performance is exhibited by the presented D-CALB for varying number of nodes in terms of throughput.

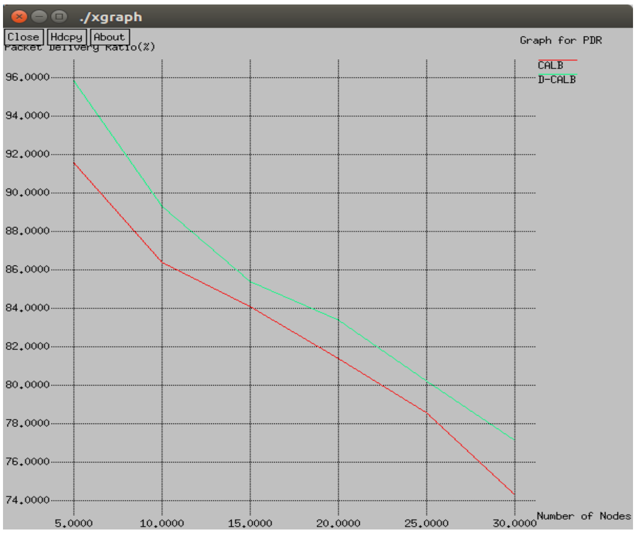

Fig. 4. No. of nodes Vs Packet Delivery Ratio

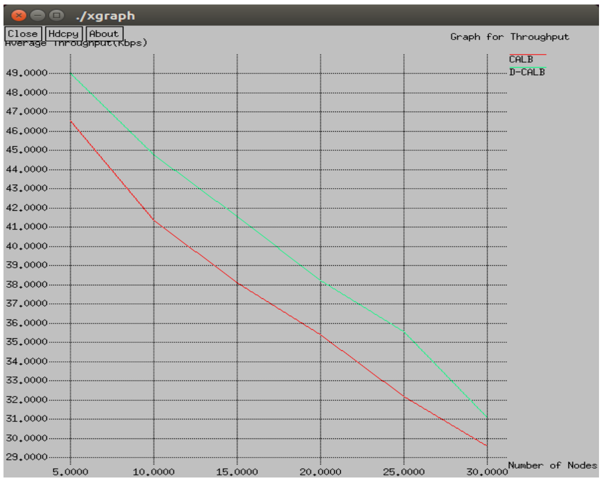

Fig.5. No. of nodes Vs Throughput

The result analysis of different routing protocols interms of average delay is made in Fig. 6. From the figure, it is evident that CALB is somewhat good outcomes, but not than proposed D-CALB in terms of average delay under a varying number of nodes. The presented D-CALB exhibits less average delay over the compared method in a significant way under a varying number of nodes. For instance, under the presence of 5 nodes, the D-CALB achieves a minimum average delay of approximately 5.5s, whereas the existing CALB attains maximum average delay values of 7.3s.

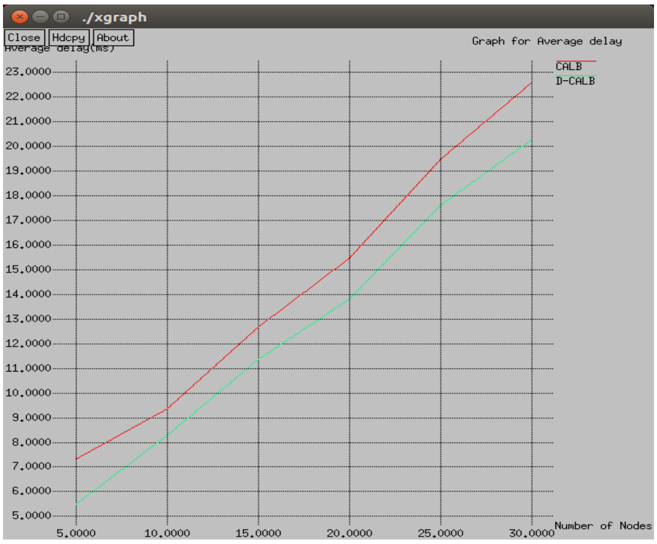

Fig. 6. No. of nodes Vs. average delay

In addition, under 15 nodes, proposed D-CALB obtains a lower average delay of 11.4s. But, the CALB show a higher average delay of 12.6s. Similarly, under the circumstance of 30 nodes, a minimum of 20.2s average delay is obtained by D-CALB. In the same case, the existing CALB attains 22.5s of average delay. Therefore, the above analysis shows the superiority of the presented D-CALB for varying number of nodes in terms of average delay.

Energy consumption analysis of the different routing protocols interms under a varying number of nodes is presented in Fig. 7. From the figure, it is evident that the minimum energy is consumed by the proposed algorithm. The proposed D-CALB is better than existing CALB interms of average energy consumption under a different number of nodes. The presented D-CALB exhibits less average energy consumption over the compared method in a significant way under a different number of nodes. For instance, under the presence of 5 nodes, the D-CALB achieves a minimum average energy consumption of approximately 5.5J, whereas the existing CALB attains maximum average energy consumption values of 7.4J. In addition, under 15 nodes, D-CALB obtains lower average energy consumption of 11.4J. But, the CALB show higher average energy consumption of 12.6J. Similarly, under the circumstance of 30 nodes, a minimum of 20.3J average energy consumption is obtained by D-CALB. In the same case, the existing CALB attains 22.5J of average energy consumption. These values verified the superiority of the presented D-CALB for varying number of nodes in terms of average energy consumption.

Figure 8 shows the result analysis of different routing protocols interms of normalized routing overhead. From the figure, it is evident that the CALB shows inferior results over the D-CALB. In the same way, the CALB manages to perform well, but not than D-CALB interms of normalized routing overhead. The presented D-CALB exhibits less normalized routing overhead over the compared methods in a significant way under a varying number of nodes.

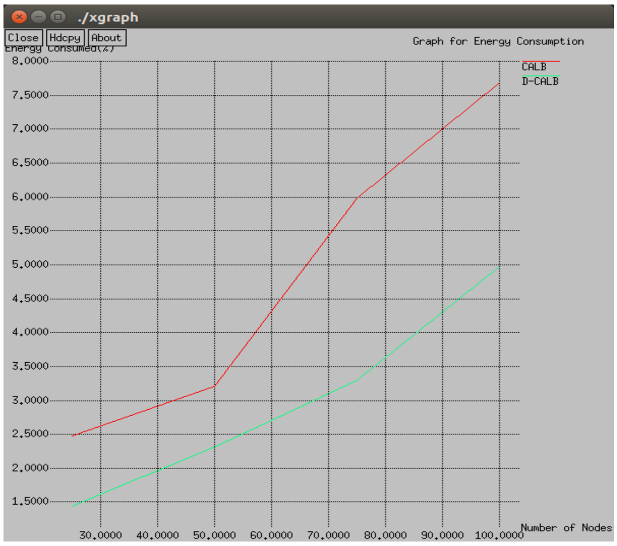

Fig. 7. No. of nodes Vs. Energy consumption

For instance, under the presence of 5 nodes, the D-CALB achieves a minimum normalized routing overhead of approximately 3.6 whereas the existing CALB attains a minimum normalized routing overhead values of 4.5. In addition, under 15 nodes, D-CALB obtains lower normalized routing overhead of 8.5. But, the CALB show higher normalized routing overhead of 10.5. Similarly, under the circumstance of 30 nodes, a minimum of 18.9 normalized routing overhead is obtained by D-CALB. In the same case, the existing CALB attains 20.3 of normalized routing overhead. These values verified the superiority of the presented D-CALB in terms of normalized routing overhead under a varying number of nodes.

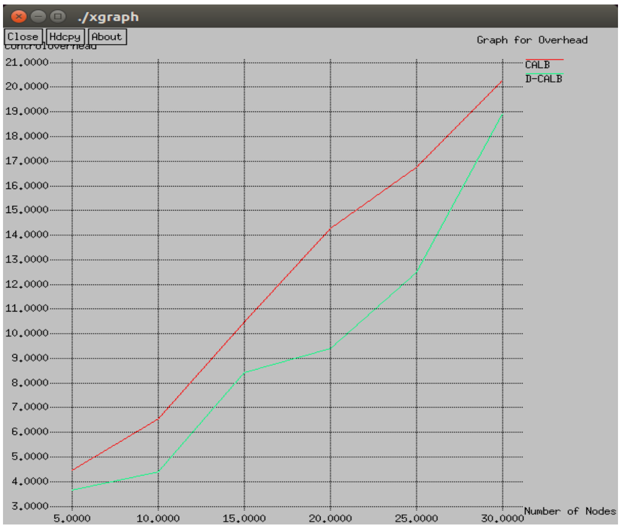

Fig.8.No.of nodes Vs Normalized routing overhead

B. Results Analysis In Terms Of Varying Speed

Figure 9 shows the analysis of the results of the proposed D-CALB under varying speed from 2 to 10 interms of PDR. From the figure, it is shown that the maximum value of PDR is achieved by D-CALB over the existing CALB. At the same time, CALB exhibits worse results with a minimum PDR compared to D-CALB. For instance, under speed as 2, the D-CALB achieves a maximum PDR of approximately 99.8% whereas the existing CALB attains a minimum PDR value of 97.8%. In addition, under 6 as speed, D-CALB obtains higher PDR of around 93.4%. But, the CALB show lower PDR of 90.4%. Similarly, under the circumstance of 10 as speed, a maximum of 87.2% PDR is obtained by D-CALBIn the same case, the existing CALB attains 85.4% of PDR. These values verified the efficiency of the presented D-CALB in terms of PDR even in the presence of different speed.

Fig. 10 shows the result analysis of different routing protocols interms of throughput under varying speed. From the figure0, it is evident that the CALB shows more inferior results over the CALB. In the same way, the CALB is better, but not than D-CALB in terms of throughput. The presented D-CALB-D exhibits maximum throughput over the compared methods in a significant way under varying speed.

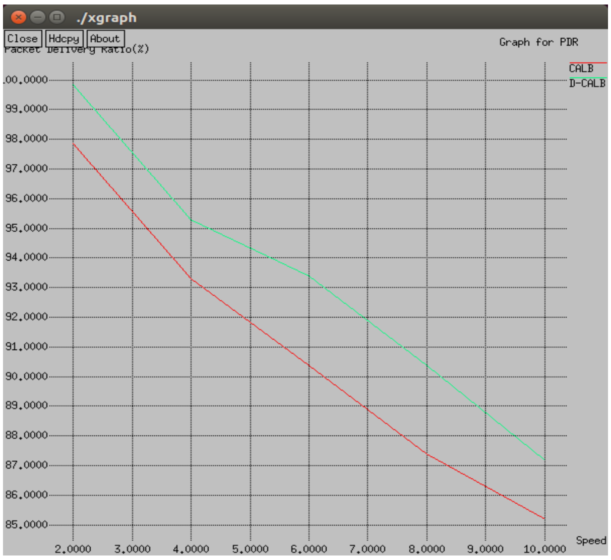

Fig. 9. Varying speed Vs. PDR

For instance, under 2 as speed rate, the D-CALB achieves a maximum throughput of approximately 56Kbps, whereas the existing CALB attains minimum throughput values of 53Kbps. In addition, under 6 as speed, D-CALB obtains higher throughput of 42.7Kbps. But, the CALB show lower throughput of 40.3Kbps. Similarly, under the circumstance of 10 as speed rate, a maximum of 32.4Kbps throughput is obtained by D-CALB. In the same case, the existing CALB attains 29.7Kbps of throughput. These values proved that the presented D-CALB is efficient for the varying speed in terms of throughput.

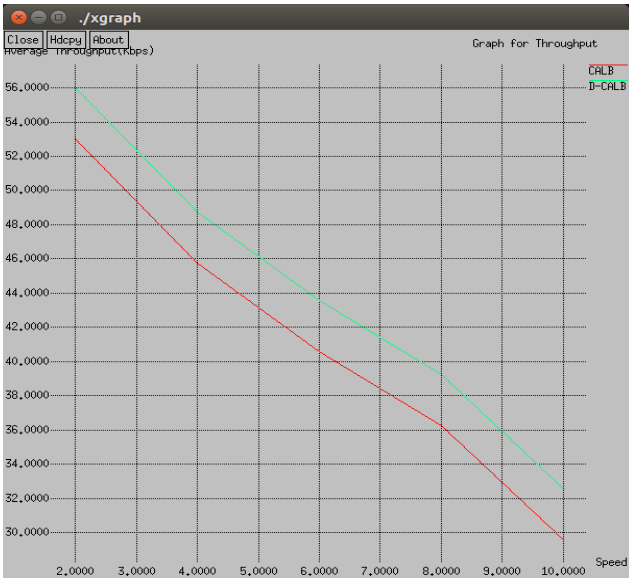

Fig. 10. Varying speed vs. Throughput

A comparison of different routing protocols interms of average delay is made in Fig. 11. From the figure, it is apparent that the D-CALB shows reduced delay results over the CALB method. In the same way, the CALB is somewhat better, but not than D-CALB interms of average delay under varying speed. The presented D-CALB showed less average delay over the compared methods in a significant way under varying speed. For instance, under the presence of 2 as speed rate, the D-CALB achieves a minimum average delay of approximately 2.5s, whereas the existing CALB attains maximum average delay values of 3.5s. In addition, under 6 as speed rate, D-CALB obtains a lower average delay of 17.4s. But, the CALB show a higher average delay of 19.4s. Similarly, under circumstance 10 as speed rate, a minimum of 20.5s average delay is obtained by D-CALB. In the same case, the existing CALB attains 22.6s of average delay.

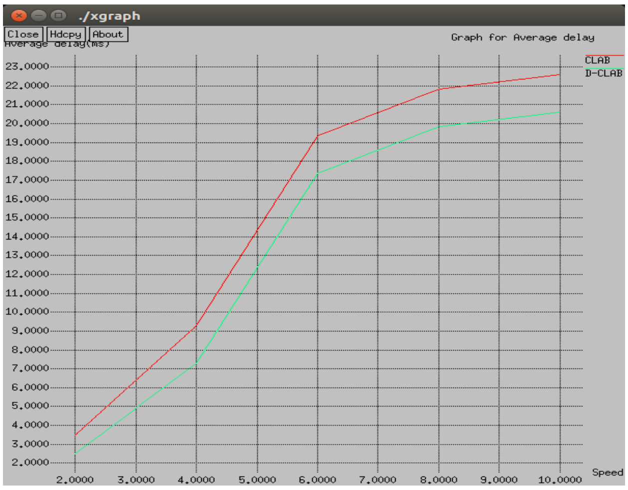

Fig. 11. Varying speed vs Average delay

These show the efficiency of the presented D-CALB for varying speed in terms of average delay.

An energy consumption analysis of the different routing protocols in terms under varying speed is presented in Fig. 12. From the figure, it is evident that the minimum energy is consumed by the proposed algorithm. Likewise, the CALB is somewhat better,

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but not than D-CALB interms of average energy consumption under varying speed. The D-CALB exhibits less average energy consumption over the compared methods in a significant way under varying speed. For instance, under the presence of 2 speed, the D-CALB achieves a minimum average energy consumption of approximately 3.7J, whereas the existing CALB attains maximum average energy consumption values of 4.7J.

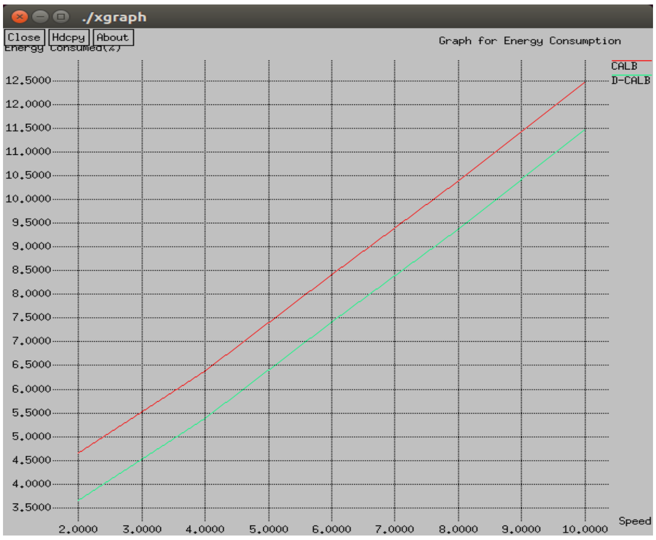

Fig. 12. Varying speed Vs. Energy consumption

In addition, under 6 as speed rate, D-CALB obtains lower average energy consumption of 7.4J. But, the CALB show higher average energy consumption of 8.4J. Similarly, under the circumstance of 10 as speed rate, a minimum of 11.5J average energy consumption is obtained by D-CALB. In the same case, the existing CALB attains 12.5J of average energy consumption. These values verified the efficiency of the presented D-CALB in terms of average energy consumption.

Fig. 13 shows the comparative analysis of different routing protocols interms of normalized routing overhead. From the figure, it is evident that the CALB shows inferior results over the D-CALB. In the same way, the CALB manages to perform, but not than D-CALB in terms of normalized routing overhead under varying speeds. The presented D-CALB exhibits less normalized routing overhead over the compared methods in a significant way under varying speed. For instance, under the presence of 2 as speed rate, the D-CALB achieves a minimum normalized routing overhead of approximately 1.5 whereas the existing CALB attains a maximum normalized routing overhead values of 2.7. In addition, under 6 as speed rate, D-CALB obtains lower normalized routing overhead of 7.5. But, the CALB show higher normalized routing overhead of 8.5. Similarly, under the circumstance of 10 as speed rate, a minimum of 10.5 normalized routing overhead is obtained by D-CALB. In the same case, the existing CALB attains 12.5 of normalized routing overhead. These values exhibit the efficiency of the presented CALB-D in terms of normalized routing overhead for varying speeds.

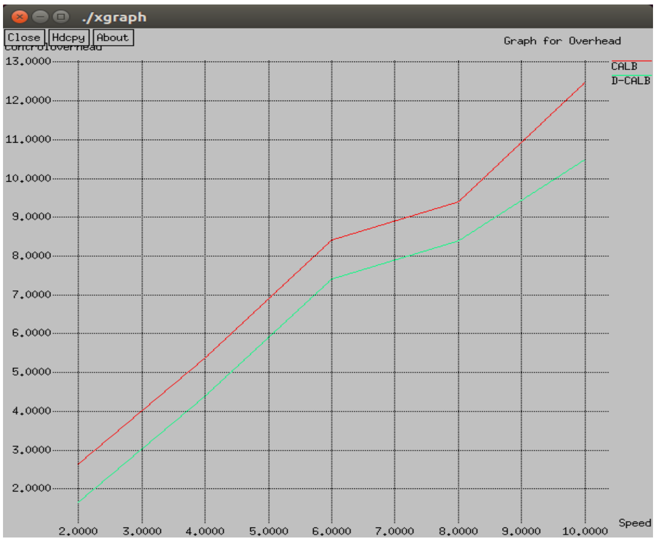

Fig. 13. Varying speed vs. Normalized routing overhead

V. CONCLUSION

In this paper, we have developed a new D-CALB algorithm for effective load distribution in MANET. The D-CALB algorithm efficiently selects the proper CHs and also effectively balances the load among the mobile nodes present in the network. The presented D-CALB algorithm offers the computation of distance among the mobile nodes to make sure they are in the transmission range of one another. Furthermore, a fault tolerant feature is included in the D-CALB algorithm, which maintains a secondary CH as a backup node in case of the failure of the present CH. The performance of the proposed D-CALB algorithm is experimented and a comparison is made with the existing CALB algorithm. In addition, the analysis of the results takes place in two ways, namely varying number of nodes and varying speed. The obtained results verified that the presented D-CALB algorithm showed superior performance over the compared method in a significant way.

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