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Dual Prioritized Energy Dependent Partitioning Approach for Energy Efficient MANET

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Abstract: In Mobile Ad hoc Network (MANET), the crucial design issue of routing protocol is to establish a correct and effective route for data transmission. Since the nodes in the MANET are typically battery-powered, energy consumption is seen as a critical factor while designing the routing protocols for such networks. Recently, the cluster based energy aware routing approaches reduces the control overheads and maximize the network lifetime Thus, in this paper a Dual Prioritized Energy Dependent Partitioning (DPEDP) approach is proposed for MANET. This approach consists of three phases such as Cluster formation, Selective node Data Transmission and Path re-imbursement. In cluster formation, the sender node become as Cluster Heads and the other with minimum connection can join the cluster with their respective cluster heads to form clusters. This phase might produce some isolated nodes. The cluster has been replenished based on the residual energy of the nodes in the network. In Selective node Data Transmission, a shortest path has been discovered using AODV and the key idea of direct diffusion is used to avoid the transmission block in the network. Additionally a sleep state adaption is processed after the shortest path selection based on some constraints. In path re-imbursement phase, a recovery mechanism is carried out in a different way when the Residual energy of the nodes in path comes down to mean transmission energy. The proposed DPEDP approach enhances the network lifetime than the existing energy efficiency approaches in MANET by minimizing the number of broadcasts, avoiding transmission blockage and effective recovery mechanism.

Keywords: MANET, DPEDP, Cluster formation, Selective node Data Transmission, AODV, Path re-imbursement, Energy Efficenicy

1. INTRODUCTION

Mobile ad hoc network (MANET) composed of nodes collaborating among themselves with transportable radios. The deployment of this type of network can be done without any centralized infrastructure. MANET supports numerous applications such as battlefields, emergency rescue service, virtual classrooms, data acquisition in hostile environments (DamianosGavalas,et, al., 2006). One of the essential metric in managing MANETs is the network lifetime. The Battery power of a node is a valuable resource which must be used effectively in order to evade quick termination of a node or a network(Senthilnathan Palaniappan and Kalaiarasan Chellan, 2015) (Visu, P, et, al., 2012). So it is essential to develop an energy efficient routing scheme to reduce the energy consumption significantly and enhance the network lifetime.

Initially, the MANET topologies were non-hierarchical networks or flat networks. From several tests and simulations conducted, it was identified that the throughput falls drastically, when the number of nodes in the flat networks grows. Furthermore,numerous factors such as unpredictable topology changes, frequent path failure, routing overhead make it challenging for a flat topology to be scalable. The clustering concept was introduced to overcome the scalability issues of a flat network. Moreover, by adopting to the topology changes, the clustering schemes can minimize the energy consumption significantly with respect to the packet drop and retransmission probability (Abbas Karimi, et, al., 2014). In clustering schemes, the mobile nodes are grouped into clusters and

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each will contain a cluster head node, which allocates the network resources to its cluster members (Dang Nguyen, et, al., 2011). A virtual backbone will be formed by all the cluster heads and communicate with each other for data forwarding. Hence, this paper uses the clustering concept and develops an approach, namely, Dual Prioritized Energy Dependent Partitioning (DPEDP) for energy efficient MANET.

This approach consists of three phases such as Cluster formation, Selective node Data Transmission and Path re-imbursement. The DPEDP approach supports the on-demand clusters, where a limited cluster formation/ maintenance overhead can be attained. Initial overhead for selecting the cluster head selection is minimized by selecting the sender as a cluster head. The cluster has been replenished based on the residual energy of the nodes in the network. In selective node data transmission, the key idea of direct diffusion is performed at the isolated nodes to minimize the retransmission energy and furthermore a sleep state adaption is carried out for energy conservation. In path re-imbursement phase, a recovery mechanism is carried out in a different way when the Residual energy of the nodes in path comes down to mean transmission energy.

The rest of the organized as follows: Section 2 presents the recent related work done for MANET based on the energy efficiency. Section 3 describes the proposed Dual Prioritized Energy Dependent Partitioning (DPEDP) approach. The discussions and results have been given in the section IV. Finally, section V renders the conclusion.

2. RELATED WORK

(Suchismita Rout, et, al., 2013 proposes a power management technique to minimize energy consumption in MANET. This approach performs routing in the distinct alternative paths, where the path does not contain a duplicate nodes and it has been attained by the clustering technique. The cluster head makes the cluster member to sleep state if there is no traffic in the path in order to save the energy.

(Srinivas Kanakala, et, al., 2014) proposes an energy-efficient coding-aware cluster based routing protocol (ECCRP) scheme for MANET. The ECCRP technique employs the networking coding at the elected cluster heads to minimize the number of transmissions. The queue management procedure The queue management process of COPE protocol (S. Katti, et, al., 2006) is modified in order to enhance the coding opportunities.

(Soumyabrata Saha, Rituparna Chaki, 2011) proposes a proposed Cluster Based Mobility Considered Routing Protocol for energy efficient MANET. In this approach a probable amount of cluster head has been selected for the MANET performance. This protocol minimizes the overhead for maintaining whole routing information for every mobile node.

(Anubhuti Roda Mohindra, Charu Kumar, 2013) proposes a location based clustering scheme for energy conservation and greater stability of clusters with position management. This scheme offers effective and quick routing with fast recovery during link failures. A two type of cluster heads is used in this scheme, namely, primary and secondary cluster heads with unique keys. In order to achieve the energy efficiency, a threshold level has been defined for capacity, power and link duration. The GPS is enabled for all the nodes and each cluster heads maintains the intra cluster and inter cluster table to manage the location services.

(Senthilnathan Palaniappan and Kalaiarasan Chellan, 2015) proposes a cross-layer based stable and energy-efficient routing scheme for MANET. In this scheme, the QoS monitoring agent is employed to collect and compute the link reliability metrics such as link packet error rate (LPER), probabilistic link reliable time (PLRT), link received signal strength (LRSS) and link expiration time (LET). These factors aid to determine the most reliable link and minimize the number of route reconstructions in MANET. Furthermore, to maintain the energy efficiency the residual energy has been implemented. At last, the probability of selecting the route is computed based on the computed metrics with the help of fuzzy logic system.

(Abbas Karimi, et, al., 2014) proposed a clustering algorithm, namely virtual links weight-based clustering (VLWBC) for energy efficient MANET. For each node, VLWBC finds the weight considering their own feature with the direct impact of neighborhood features. This is accomplished through finding weights of virtual links that make communication among the nodes in the network. Initially, the VLWBC scheme determines the weight of virtual links between two nodes. Afterwards, a resultant weight of every node is computed based on the weight of its virtual links. Finally, based on the weights a node will select as a cluster head and the efficiency of the node selection increases.

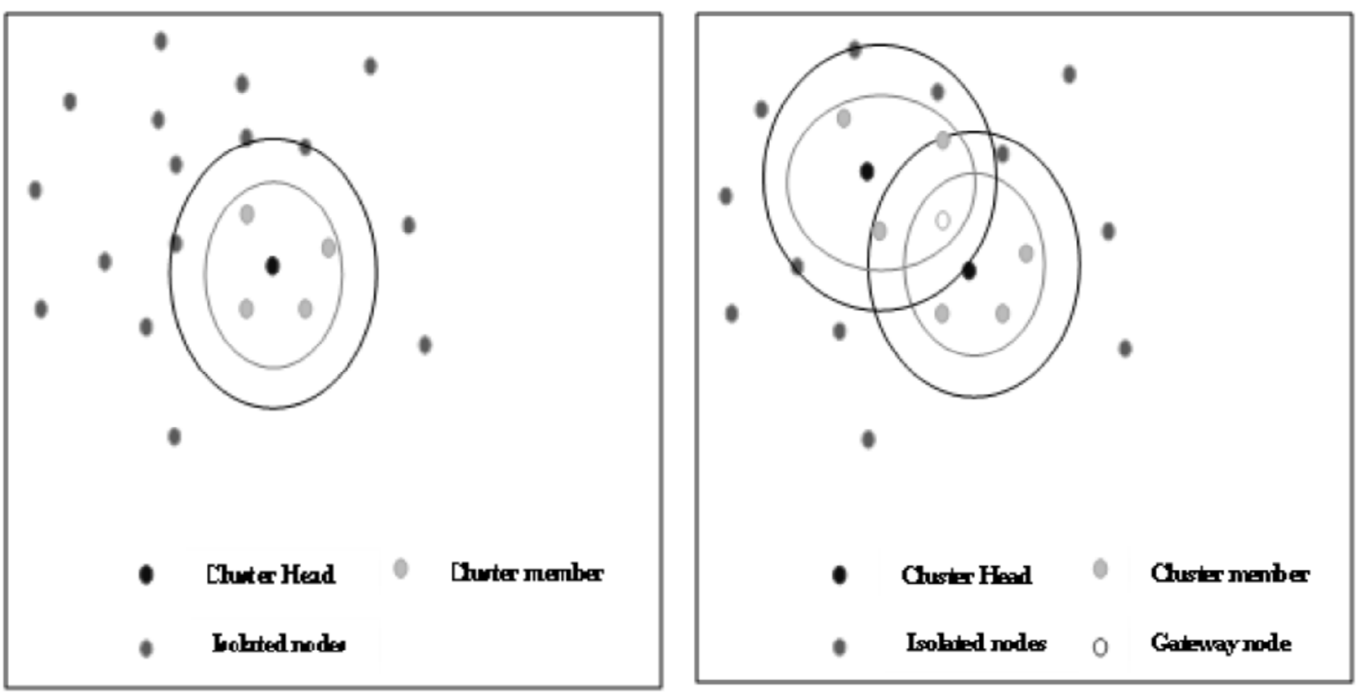
3. DUAL PRIORITIZED ENERGY DEPENDENT PARTITIONING (DPEDP) FOR ENERGY EFFICIENT MANET

Dual Prioritized Energy Dependent Partitioning (DPEDP) is a cluster based approach, where the clusters have been formed in an on demand basis. The DPEDP has been designed for lifetime improvement of MANET by an optimal energy consumption. It has been composed of three phases such as cluster formation, Selective Node Data Transmission and Path re-imbursement.

3.1. Cluster Formation

A DPEDP forms a finite amount of clusters with a good Cluster Head distribution for anenergy efficient network operation. In DPEDP, the clusters have been formed on an on-demand basis to minimize the overhead of cluster maintenance. Generally the node that desires to transmit data will form the cluster with members that falls within its transmission range and it has been shown in figure 1 (A), where the transmission range of a sender node has been represented in the black circle. (Note that the transmission range is not considered to its extent, i.e., nodes at the boundary will not be considered as a cluster member). Suppose at any point, if a cluster member of a group needs to transmit data, it does not form a new cluster, it simply transmits the data to its cluster heads which perform data transmission. If a node that is isolated from a cluster desires to transmit data it forms the cluster and it will act as a cluster head and members will be the nodes that fall within its transmission range, which is shown in figure 1 (B). The node which belongs to the two clusters will act as a gateway node.

The cluster head will maintains the information about the residual energy of its cluster members in the descending order. The residual energy is the left over energy at each node, i.e., the energy remains after the



(a) (b)

Figure 1: Cluster Formation

data transmission and reception of packets. The residual energy *RE* can be estimated by using the following equation

$$RE = IE - CE_t \tag{1}$$

Where *IE* is the initial energy of a node, CE_t is the consumed energy after a duration *t*.

Whenever the cluster head has a less residual energy than its cluster members, the cluster has been replenished by changing the cluster head. Particularly, the cluster head will become the cluster member and a node with highest energy will be selected as the next header. A stable clusters have been formed using DPEDP, where the frequent clusterhead election process is avoided and thereby minimizes the overhead involved in this process.

3.2. Selective Node Data Transmission

Initially, the node which likes to transmit the data will discover the shortest path using the AODV. If the sender node is an isolated node, then it will form the cluster and transmit the route request (RREQ) packet to the gateway node and the border nodes. Otherwise, if the sender is a cluster member then it forwards the RREQ packet to its cluster head and the cluster head will forward the RREQ packet to the gateway node and the isolated node. If the RREQ packet is received by the isolated node, it will simply broadcast the RREQ packet to its neighbors. When the RREQ packet reaches the destination, then the route reply (RREP) packet will be sent back to the source on the reverse path. The shortest path will be selected by the source node for data transmission. In particular, the selective node data transmission has been applied at the isolated nodes to reduce the energy consumption due to the retransmission occurred by the transmission blockage, i.e., the TCP flow length of a node effects unfairness, where the greater flows indicate longer round trip time and great packet drop probability. In order, to identify the node will going to be congested soon, mean_size of queue (T. SenthilKumaran, et, al., 2011) has been computed as follows

$$mean\_size_{queue} = (1 - w_q) \times mean\_size_{queue} + InstQue \times w_q \tag{2}$$

Where w_q is the weight of the queue and it has been set to 0.02 from RED queue simulation result (Gui *C*, Mohapatra *P*, 2008) and the Inst_Que is an instantaneous queue size.

The Queue conditions over mean queue size is computed using the equation (3) to acquire the useful information about the incoming traffic. While the queue condition value is large, the incoming data traffic becomes bursty traffic. The significant increase of the queue_condition represents that the incoming traffic is further than the nodes buffer capacity

$$Queue_{condition} = Inst\_{queue} - mean\_size_{queue} \tag{3}$$

If $Queue_{condition} < 25\% \ (buffersize)$, the incoming traffic is low and the condition of queue is in safe zone. If $Queue_{condition} > 25\% \ (buffersize)$ and the $< 75\% \ (buffersize)$, the incoming is average and the queue condition is to be in congested zone. If $Inst_{Que} > 75\% \ (buffersize)$, the incoming traffic is great and queue is in congested area.

Whenever the mobile node *X* is identified that is to be in congested zone quickly, then the selective node data transmission is applied in that area.

The mobile node *X* and two or more nodes under each other coverage region and the mobile node *X* send the Hello message to that nodes about the incoming traffic of the particular source node and the destination information. The node which has the path to the destination and in safe zone are allowed to make a direct diffused transmission, passing RTS copy to the source intimating the change of node to the relay node for that data transmission, where the source can either accept or reject the new RTS from the intermediates.

A sleep state adaption is applied to the nodes based on the two conditions: there must be no interfering node in the forwarding direction and the routing path must not form a Directed Acyclic Graph (DAG). Another consideration is that the number of broadcast must not be increased due to dead end problem.When a dead end

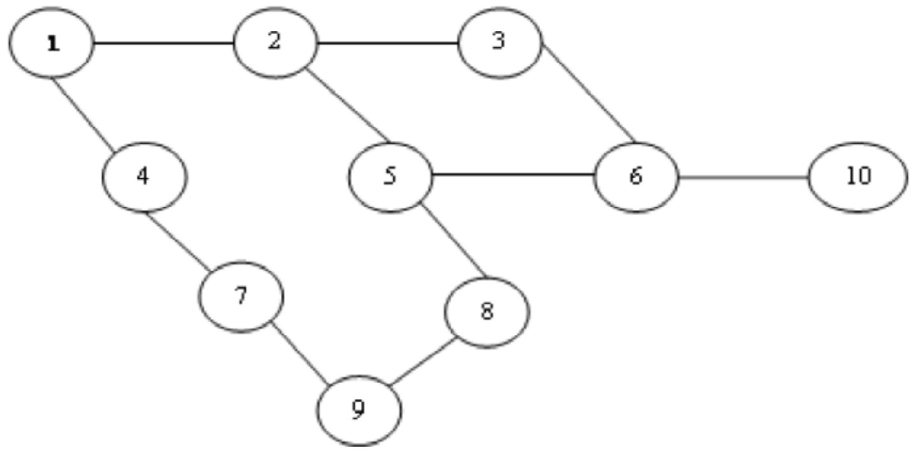


Figure 2: Sleep State adaption

node occurs too, the node must adapt SS. In the figure 2, node 2 and 5 are inferring nodes and node 10 is a dead end node.

3.3. Path re-imbursement

The DPEDP enhances the packet delivery ratio to a certain level by using the path re-imbursement mechanism when compared to the existing scheme DEECF (Yuna Kim, et, al., 2013). In the path re-imbursement phase, each of the intermediate is checked for its residual energy (RE) by using the equation 1.Furthermore, the mean transmission energy for transmitting l-bit packet from the source to destination is also accounted and these two metric aids in finding that a intermediate node has a sufficient power to perform the task given by the source node. The energy required to transmit a l-bit packet from a node i to the next node j at a distance d is given as follows

$$T\,E_{i \to j}\,(I, d) = Elec \times k + Eamp \times l \times d^2 + b \qquad (4)$$

Where Elec is the energy dissipation of radio transceiver circuitary, Eamp is the energy required to run the transmit amplifier and b is the channel cost

By using the equation 4, the mean transmission energy of a path require to transmit a packet from source to destination has been computed as follows.

$$\overline{TE} = \frac{\sum_{i=1}^{n} TE_i}{n}; n \text{ is the number of nodes in the path} \qquad (5)$$

While the RE of a intermediate node is less than the $\overline{TE}$, then a data is fragmented according to that RE and transmitted on that path. After that the remaining data will be transmitted via the secondary paths based on the above mentioned condition. If almost all the nodes are in non-transmission statei.e to 80% of its transmission enrgy has been lost, an mobile collector in the form of relay has been deployed to gather data. The mobile collector shifts the path randomly based on the availability of the nodes, that are ready to transmit a RTS for confirming a path. Algorithm for the proposed DPEDP has been given in the Algorithm 1.

4. SIMULATION SETUP

The proposed DPEDP protocol composes of threes phases tries to extend the entire network lifetime. The NS2 simulation has been used to test the performance of the proposed DPEDP protocol and the simulation setup is shown in the table 1.The performance of the DPEDP protocol is compared with other protocols such as Weighted Clustered Algorithm (WCA), Distributed Energy Efficient Cluster Formation (DEECF). The Performance of the protocol is measured in terms of packet delivery ratio, routing overhead and cluster reaffilation.

Algorithm 1
DPEDP algorithm for Energy Efficient MANET

1. **Cluster Formation and data forwarding**
2. *$Node_i$ needs to transmit a packet*
3. *If $i \in$ Any of the cluster*
4. *Transmit data to CH*
5. *CH broadcast the RREQ packet*
6. *else If i is isolated node*
7. *i is elected as cluster head*
8. *Select the neighbor node as cluster member by excluding border nodes*
9. *Broadcast RREQ packet*
10. *End if*
11. **Cluster Reaffilation**
12. *For i to n; n is the number of clsuters*
13. *For j to m; m is the cluster memebers of i*
14. *Store the RE of its cluster members in an Array $A[RE \rightarrow CM_j]$*
15. *Sort the array A in descending order*
16. *End for*
17. *If $RE[CH] < \forall CM$*
18. *Change the CH with $MAX[A[RE \rightarrow CM_j]$*
19. *End for*
20. **Selective Node Data transmission for isolated nodes**
21. *Node I is a relay for a particular data transmission of source node s*
22. *If $i \in$ normal state*
23. *For j =1to n (neighbor nodes of i)*
24. *If j knows the path to the destination*
25. *J send RTS to S for initiamating the change of node as relay node for that data transmission*
26. *End if*
27. *End for*
28. *Sleep state adaption is performed for the nodes, which does not have any interfering node in the forwarding direction and does not form DAG*
29. **Path re-imbursement**
30. *If the nodes in the entire network consumed 80% TE*
31. *Deploy mobile collector*
32. *Collect the data from the nodes and shifts the path randomly according to the number of RTS packet from a path*
33. *else*
34. *For i to n; n is the number of sources tries to transmit their data packets*
35. *For j to m; m is the number of nodes in the path $X \rightarrow i$*
36. *If $RE[j] < \overline{TE}$*
37. *Fragments the packet based on the RE[j]*
38. *Transmit the fragmented packet to path X*
39. *End if*
40. *Select the next secondary path to transmit the remaining packet by following the step 31 to 37 until the entire packet has been sent*
41. *End for*
42. *End if*

Table 1
Simulation Setup

Simulation Parameter	*Value*
Simulator	NS-2 (v2.34)
Topology size	1000 × 1000 m
Number of nodes	20, 40, 60, 80, 100, 120
Transmission range	200 m
Bandwidth	2Mbps
Interface queue length	100
Traffic type	CBR
MAC type	802.11
Packet size	512 bytes
Paused time	0s
Speed	5 m/s

4.1. Performance metrics

Packet Delivery ratio

Packet delivery ratio is the fraction of data packets delivered to the destination node, to those packets transmitted by the sources.

$$PDR = \frac{Total\ number\ of\ packet\ successfully\ delivered}{Total\ number\ of\ packet\ sent} \times 100 \quad (6)$$

Residual energy

It is the average residual energy of the nodes in the network after the completeion of the simulation period

Normalized Routing Overhead

Normalized routing overhead is the amount of control packets per data packets transmitted in the network

4.2. Discussion

Figure 3 shows the average number of CH changes with respect various network size, which is an best sign of the overall cluster organization stability (the frequent change in Cluster head, the minimum stable clusters are resultant).

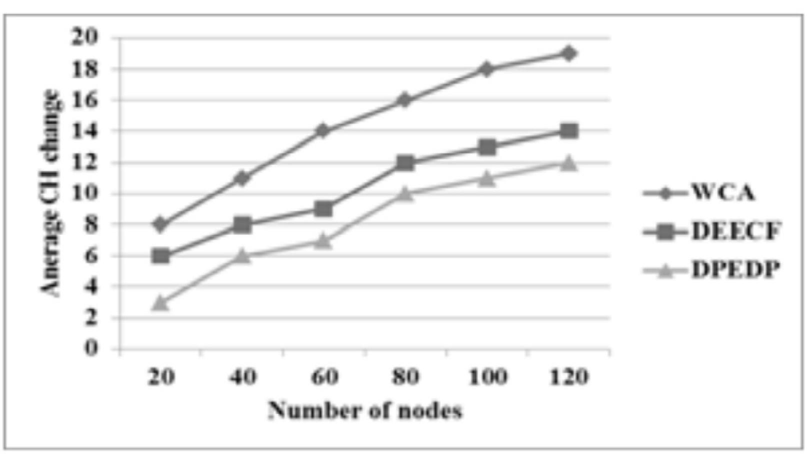


Figure 3: Cluster reaffilationwith respect to Network size

WCA includes the degree metric to form the clusters where it badly impact on the cluster stability due to nodes movement. Meanwhile, if the network size grows, it is more likely to perform the reaffilation of the clusters. While the DEECF does not depends on the node mobility rather than it depends on the battery drainage. DPEDP also depends on the battery drainage for reaffilation, but the CH change will occur only the residual energy comes under the all the cluster member residual energy rather than using a threshold energy like DEECF. As expected, DPEDP has minimum cluster head change when compared to the DEECF and WCA.

The DPEDP may incur some routing overhead due to forwarding the the control messages RTS and CTS packet in the Selective Node Data Transmission but it reduces the control message in the cluster formation and the maintenance phase. In WCA, the routing overhead is more due to excuting the reclustering whenever the node moves out of the cluster. DEECF incurs somewhat high routing overhead in the cluster maintenance phase than the DPEDP and less than the WCA. Figure 4 shows the average number of control messages dissiminated as increase in simulation time. The DPEDP disseminates 130 control message for 180s, while the DEECF and WCA dissiminates 190 control messages, 800 control messages respectively

In DPEDP, the energy optimization has been carried out by using three different phases. While the WCA and the DEECF concentrate only on the cluster formation and maintence phase. The DPEDP reduces the transmission energy consumed for the retransmission due to the congestion by performing the direct diffusion based data transmission. The path reimbursement phase performs effective data transmission at the time of high energy depletion

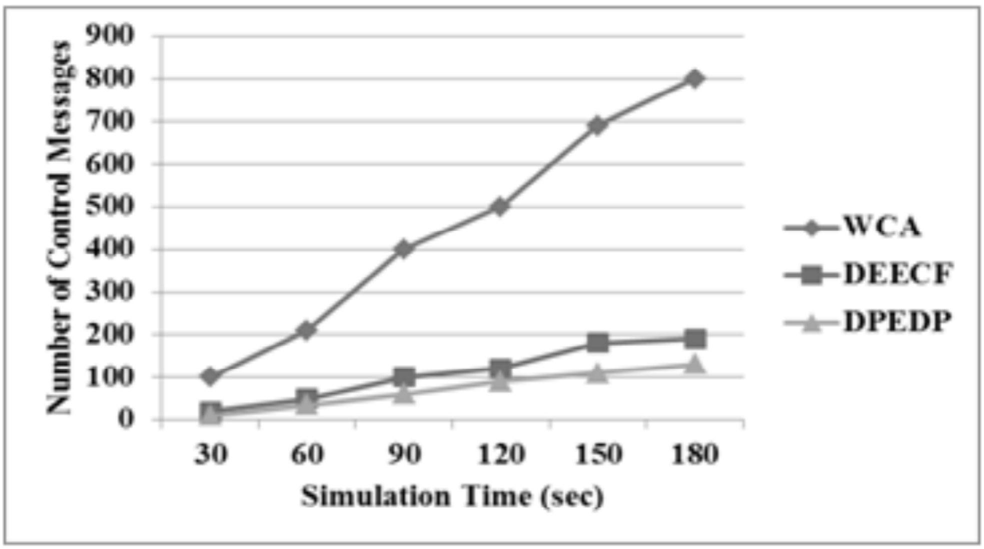


Figure 4: Routing Overhead with respect to Simulation time

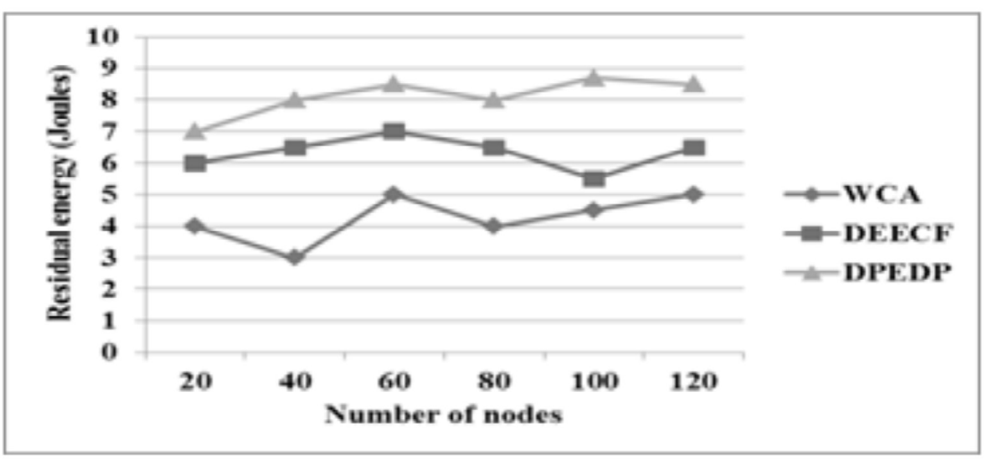


Figure 5: Residual energy with respect to network size

in the network. As expected the DPEDP performs better than the DEECF and DCA interms of energy efficiency. Figure 5 shows the residual energy with respect to various network size. The DPEDP has the residual energy of 5J for 120 nodes, while the DEECF, WCA has the residual energy of 6.5J, 8.5J respectively.

Figure 6 shows the packet delivery ratio with respect to the number of nodes in the network. In DPEDP, the packet delivery ratio is increased by choosing the path that is less congested with high energy efficient. The DPEDP attains 95% packet delivery ratio for 120 nodes, while the DEECF and WCA attains 92%, 85% respectively.

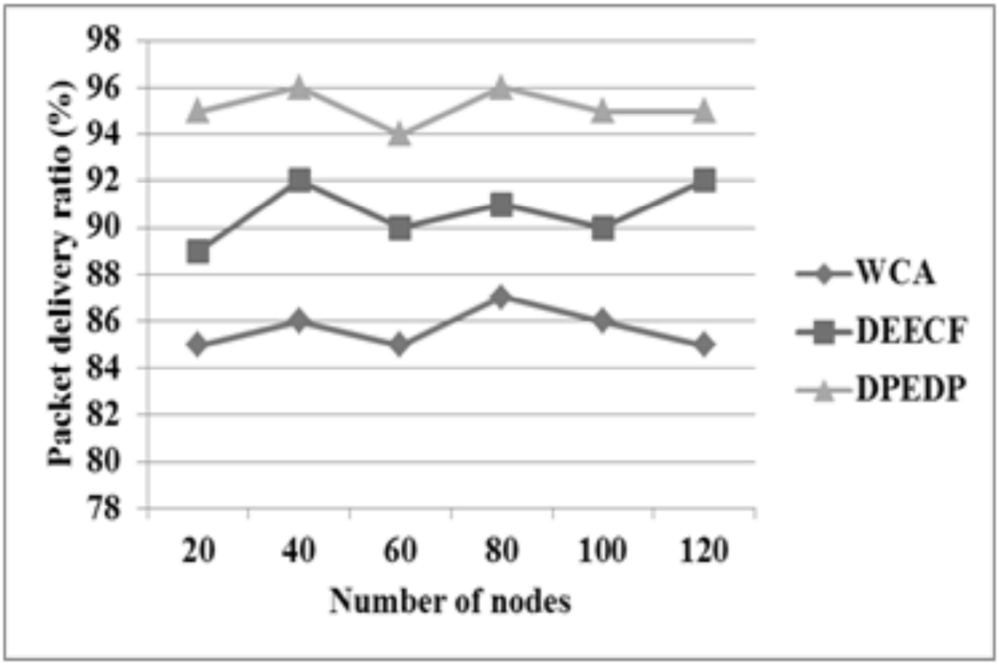


Figure 6: Packet delivery ratio with respect to Network size

5. CONCLUSION

This paper proposed a Dual Prioritized Energy Dependent Partitioning (DPEDP) approach for Energy efficient MANET. The DPDEP composed of three phases such as Cluster formation, Selective node Data Transmission and Path re-imbursement. The cluster formation based on on-deamnd and the cluster reaffilation based on residual energy attains minimum overhead than the existing cluster based MANET. The key idea of direct diffusion is used in the Selective node Data Transmission to avoid the transmission block in the network, where the energy required for the retransmission has been avoided.Additionally a sleep state adaption has been carried out after the route selection inorder to conserve the energy.In path re-imbursement phase, the throughput and packet delivery ratio has been enhanced by considering the residual energy of the nodes and the mean transmission energy of the selected path

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