Deterministic Directed Flooding Scheme (D2FS) for Inter-Cluster Flooding in Mobile Adhoc Networks

S.Mahima, N.Rajendran

Abstract*: Mobile Ad hoc Networks (MANET) comprises a collection of numerous mobile nodes that communicates with one other with no dependence on any predefined infrastructure in the network. The characteristics of MANET such as independent, wireless, and self-configuration of MANETs allows the suitability of various application scenarios. Cluster based Flooding is an important issue in the design of MANET where it is an order to manage data traffic as it utilizes a set of chosen nodes to transmit data between two nodes. MANET networks frequently structured with mobile devices for enabling data transmission. An essential process of selecting forwarding set in the inter-cluster flooding. The routing protocol employ in the network often defines the energy efficiency and network performance in ad hoc networks. This paper presents a new deterministic directed flooding scheme (D2FS) for effectively choose the forwarding set for effective inter-cluster flooding. In addition, a Cluster Based Flooding utilizing Fuzzy Logic Scheme (CBF2S) to effectively transmit data is also presented. The devised D2FS model is tested using NS2 tool with respect to the existence of diverse hop counts. An extensive experimentation takes place to prove the superiority of the D2FS with respect to overhead, communication overhead, traffic load, packet delivery ratio and end to end delay.

***Keywords* : Forwarding set; Clustering; Flooding; MANET.**

I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) holds numerous mobile nodes connected through wireless connections. A node could straightly link with the nearby nodes with no dependency on any predefined structure in MANET. Precisely, a packet transmitted by mobile nodes in MANET will be received by every other node present in its communication range [1]. As each node in MANET could not straightly connect with the nodes present out of the transmission range, a request packet will be broadcasted many times while relaying the nodes for ensuring the successful delivery of packets at every node.

The wireless and self-configurable nature of MANET makes it suitable for diverse application scenarios like disaster management, border control and so on. Some other applications are data collection, virtual classrooms and momentary local area network [2]. A common and fundamental procedure in MANET is the nature of broadcasting where an origin node transmits a packet which needs to be distributed to every other node in MANET. In 1-to-all model, communication of every node could be received by individual nodes present in the communication range whereas the 1-to-1 model undergo the stimulation of every communication to a isngle nearby node by the use of narrow beam directional antennas or individual frequency of every node [3]. It could be employed in the route discovery reactive approaches in MANET. For instance, in Dynamic Source Routing (DSR), Zone Routing Protocol (ZRP), Ad Hoc On-demand Distance Vector Routing (AODV) and Location Aided Routing (LAR), broadcasting of route request packets takes place. Each node holds a broadcast ID and node name from which the packet is attained. Once it reaches the destination, a response with a unicast (point-to-point) packet is sent and every intermittent node has the capability of establishing the return route.

Flooding is commonly used for broadcasting. Each node, that receives a broadcast message for the first time, rebroadcasts it to its neighbors as shown in Fig. 1 [1]. The single 'optimization' employed in this method is that the node should identify the broadcast messages received and it should not rebroadcast when it receives redundant copies of the identical message [4]. It is easier and requires only few resources in the node. It provides reliability at the cost of more overhead in MANET. The possibility of many requests concurrently for accessing the medium is too high and the collision count gets dramatically increased leading to many packets dropping. This situation is generally termed as broadcast storm issue [5]. Several studies defined this issue through depicted the seriousness by analysis and experiments.

A probability based flooding model is presented in [6, 7] by the reduction of repeated rebroadcasting and eliminating the broadcast storm issue. Under this method, on the reception of broadcast messages at the beginning, a node will rebroadcast the message with a fixed probability value p; each node holds identical possibility of rebroadcasting the messages. Once the maximum probability of 100% is reached, this method gets reduced to simple flooding.

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***** Correspondence Author
S. Mahima, Ph.D. Research Scholar, Department of Computer Science, Periyar University, Salem, India. Email: blessiejohnj@gmail.com
N. Rajendran, Principal, Vivekanadha Arts and Science College for Women, Salem, India. Email: vpnraj@gmail.com

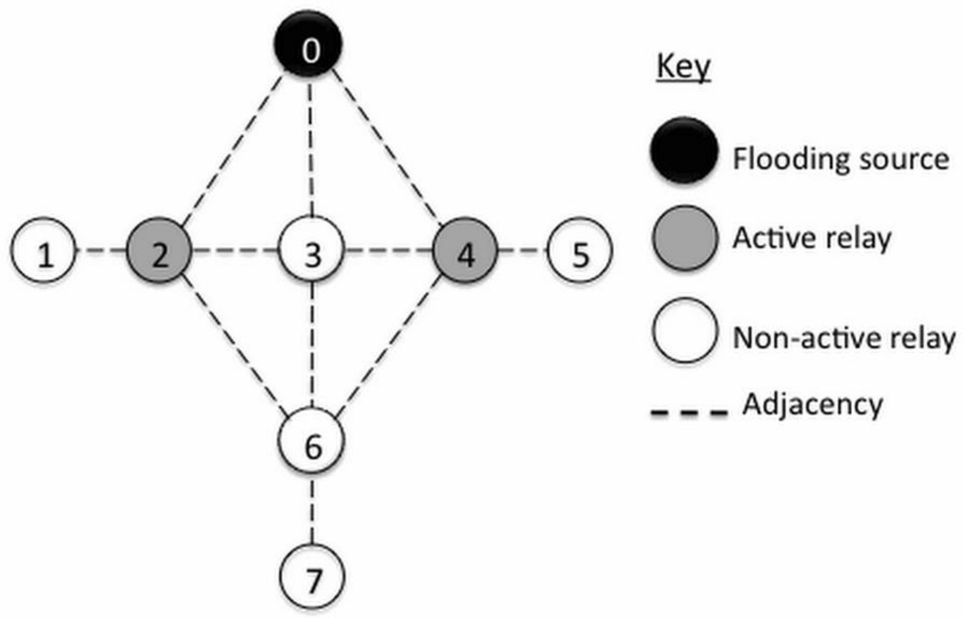

Figure 1: Flooding process in MANET

[8] analyzed the flooding techniques in a detailed experimental way. The attained outcome represents that the rebroadcasting process offers almost 61% extra coverage. So, rebroadcasting process is expensive. [9] classifies the broadcasting methods into 5 types for reducing the redundancy, collision and contention and the types are probability, distance, counter, location and clustering based models. This work mainly concentrates on the routing based model which partitions the MANET to a number of clusters which holds a subset of nodes. Every individual cluster holds a cluster head (CH) and many gateways. CH is the leader of the cluster which rebroadcasts can include every node present in it. The gateways only have the ability of the communication with other clusters and have the responsibility of propagating the packets to other clusters.

Another categorization of broadcasting models in MANET takes place in [8] based on simple flooding, probability-based, area-based, and neighbor knowledge model. At the first type, every node will retransmit it to the nearby nodes as a reply to each fresh attained packet. At the second type, each node will transmit the nearby node as a reply to each freshly received packet. At the third type, an easier way to control flooding of messages is given using a predefine probability [10]. At the fourth type, a node will determine the time of packet rebroadcasting [3]. At the final type, details related to the nearby nodes will be maintained to decide the choice of rebroadcasting node. For utilizing the final type, every node has to openly swap neighborhood details between the mobile nodes by the use of regular hello packets. The period length will affect the results of this model. The shorter time period will leads to the collision or contention whereas the longer time period degrades the model's capability to manage with the mobile nature.

Cluster based Flooding is an important issue in the design of MANET where it is an order to manage data traffic as it utilizes a set of chosen nodes to transmit data between two nodes. MANET networks frequently structured with mobile devices for enabling data transmission. An essential process of selecting forwarding set in the inter-cluster flooding. The routing protocol employ in the network often defines the energy efficiency and network performance in ad hoc networks. This paper presents a new deterministic directed flooding scheme (D2FS) for effectively choose the forwarding set for effective inter-cluster flooding. In addition, a Cluster Based Flooding utilizing Fuzzy Logic Scheme (CBF2S) to effectively transmit data is also presented. The devised D2FS model is tested using NS2 tool with respect to the existence of diverse hop counts. An extensive experimentation takes place to prove the superiority of the D2FS with respect to overhead, communication overhead, traffic load, packet delivery ratio (PDR) and end to end (ETE) delay.

The remaining sections are arranged here. Section 2 introduces the presented D2FS model whereas Section 3 validates it. Atlast, section 4 concludes the work.

II. PROPOSED D2FS MODEL

2.1. Cluster based flooding

As clarified previously, flooding is a significant method to oversee traffic since it utilizes just the picked nodes known as gateways, for diffusing REQ packets. The utilization of gateway nodes is to lessen the flooding of communicate messages in the system through the decrease of repeated retransmission in a similar territory. At first, CBF2S model is connected for the association of versatile nodes in MANET into clusters. To build groups and pick appropriate CHs, fuzzy based approach is connected with the utilization of three parameters in particular link quality, node mobility and node degree as shown in Fig. 2. The displayed model significantly limits the number of retransmissions in the system. The CMs are changed into gateways when they got messages from various CHs.

Each CM in the cluster can peruse and process the packet, yet it can't send the communicate message. This technique impressively limits the quantity of retransmission in flooding or communicates the process in dense networks. Along these lines, gateway nodes can retransmit the messages between the packets in a various leveled way. In addition, gateway nodes can retransmit a bundle starting with one gateway then onto the next for limiting undesirable retransmissions, and just when the gateway goes under an alternate CH.

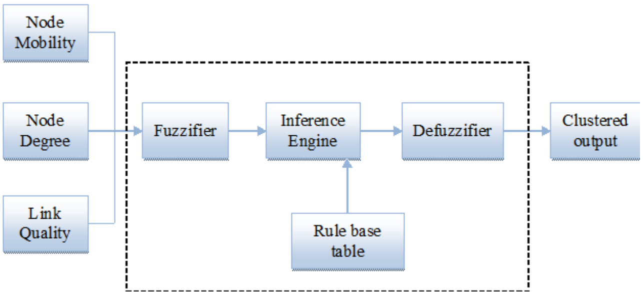

Figure 2. Fuzzy logic process

2.2 Forwarding set selection using D2FS

D2FS model comes under the type of geographical routing protocol. It has a consideration that every node knows their position and its adjacent node's position. So, the forwarding set in the geographical advances towards the destination has to be chosen. The nature of wireless connections is highly vulnerable to packet losses. So, when a present forwarding node identifies weak connections to its nearby node, D2FS arranges many nodes will function as the subsequent forwarding node set for increasing the probability of the packet to reach the destination in a reliable manner. Else, some forwarding nodes are sufficient for making the packets reach the destination. This process will take place at every hop count.

Under the kind of controlled flooding, packet transmission is generally carried out. A set of two essential angles are present namely [11]: (1) PRESENT ANGLE of a node i (〖PA〗 _i) and (2) REFERENCE ANGLE of earlier node j (〖RA〗 _j). From Fig. 3, the 〖PA〗 _i of a forwarding node F indicated that the included angle of two lines are FS and FD, where S and D indicates the source and destination nodes. In addition, (〖RA〗 _j), a REFERENCE ANGLE value assumed by the earlier node E which is applied for F for taking decision of forwarding a received packet or node. In case of forwarding a packet E, the broadcasting of packet takes place to its nearby nodes with decide whether to forward the received packet. When P has a packet to forward, it broadcasts the packet to its neighbors with 〖RA〗 _j. But, few of the nearby nodes present in a particular region only participate in the packet transmission. Therefore, the flooding of packets is avoided in the entire network. The flooding region is generally constructed based on the quality of link of the nearby nodes present in every forwarding node. Upon a reception of a packet forwarding node F from C, F determines the 〖PA〗 _i and undergo comparison with the 〖RA〗 _j saved in the packet.

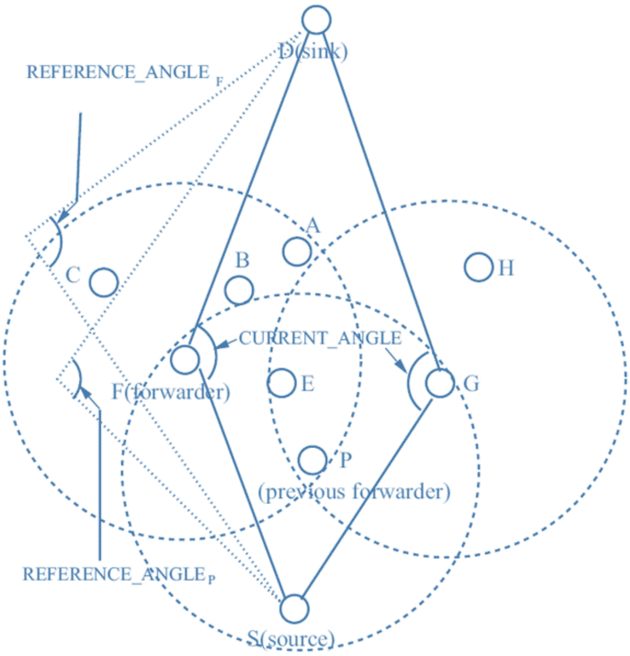

Figure 3: Packet transmission in D2FS

When the PA_i is identical or higher than RA_C, it is concluded that it comes under the region of flooding. Next, rebroadcasting of the packet takes place from F comprising the updated RA_F based on the link quality to its nearby nodes. Hence, the flooding of packets takes place towards the BS with no dependency on the route establishment between the source and destination. At the process of forwarding, void problem takes place due to the fact that D2FS make use of greedy forwarding. This study identifies two kinds of void problem based on the reason of existence: i) when a new flooding region incorporates zero forwarding nodes and (b) when no nearby nodes are located near to the destination. The D2FS manages the issues through the needed of the flooding region to involve the minimum of one node as the forwarding nodes.

Additionally, in case of not have any nearby nodes nearer to the destination, path detouring towards the destination take place by the D2FS. It will simply deliver the packets by flooding process instead of a constructed route. Besides, every forwarding node could update the size of the flooding region through the adjustment of the REFERENCE ANGLE value. Hence, the advantages of employing REFERENCE ANGLE are three-folded. Initially, minimum routing overhead is attained. As D2FS is not dependent on the constructed route among the two nodes, none of the control message is needed to maintain the path. Next, a minimum transmission overhead is needed. Then, it is found to be reliable. The nodes which are present in the flooding region only get involved in the forwarding. But, in case of poor link quality is bad, the flooding region size will be high to incorporate many nodes. Therefore, reliable delivery of packets can be enhanced.

Packet transmission

At the beginning, a transmitting node T will broadcast a packet comprising the position, starting REFERENCE ANGLE value. The first REFERENCE ANGLE value is considered as a fixed minimum angle (A_{MIN}) based on the network density. As shown in Fig. 3, it is assumed that the packet arrives at a node P and rebroadcasting of packet P takes place comprising its updated REFERENCE ANGLE value, RA_j. On the reception of a packet P from the forwarding node F, a decision will taken whether forwarding of packets by undergoing a comparison between PA_i and RA_j. The value of PA_F can be attained using cosine law as given in Eq. (1):

$$PA_F = \arccos\left(\frac{|Ft|^2 + |FD|^2 - |TD|^2}{2 \cdot |FT| \cdot |FD|}\right) \qquad (1)$$

When PA_F is lower than RA_p, F will discard the packet due to the fact it is treated out of the flooding region. When it is decided that F is present in the flooding region, F will adjust RA_F and involves in packet forwarding. When none of the nearby node is present and kept nearer to the destination compared to F, then F will execute the void handling procedure as given in Eq. (1). Once the average link quality A_{LQ} to the nearby nodes towards the destination is not good compared to the fixed threshold value LQ_t, F will set RA_F to the value of $RA_p - A_{DCR}$, where A_{DCR} represents the fixed decrement value. It enables many nodes in the participation of packet forwarding. At the same time, when A_{LQ} is higher than the LQ_t, F will be set to RA_F to the value of $RA_p + A_{ICR}$, where A_{ICR} is a fixed increment value. It makes few nodes for participating in the packet forwarding:

$$RA_F = \begin{cases} RA_p + A_{ICR} & if\ AvgLQ > LQ_{th} \\ RA_p, & if\ AvgLQ = LQ_{th} \\ RA_p - A_{DCR} & if\ AvgLQ = LQ_{th} \end{cases} \qquad (2)$$

On the modification of the RA_F, F will set the forwarding set. It may be higher than the one node in the flooding region. When each node will transmit the packet concurrently, collision takes place. A forwarding delay could be applied for alleviating the collisions. The forwarding node F set its forwarding delay based on the distance to destination and link quality to the nearby node. When the position of the F is nearer to the position of P. Besides, a better link quality allows the forwarding delay be low. As given in Eq. (3), where α and β is the weight factors in good turn with the go forward in distance towards the destination and link quality, correspondingly, Dist(X) is the distance among the node X and destination. The T_r is the transmission range of the node, and Max_{PD} indicates the maximum propagation delay. When $\alpha = 1\ and\ \beta = 0$, the forwarding delay completely helps the advancement in the distance towards the destination. At the same time, when $\alpha = 1\ and\ \beta = 0$, the forwarding delay completely based on the link quality. Here, the values of α and β is kept as 0.5.

$$Forwarding\ delay = \left(\alpha\left(1 - \frac{Dist(F) - Dist(P)}{T_r}\right) + \beta\left(1 - \frac{1}{A_{LQ}}\right)\right) \times Max_{PD} \qquad (3)$$

When F overhear the identical packet in prior to the expiry of forwarding delays, F represses its forwarding. Else, F begins the process of forwarding the packets.

Measuring ETX

ETX defines the expected number of transmissions of a data packet on the successful reception of the packet at the destination. It is provided in Eq. (4) where d_f and d_r indicates the forward and reverse delivery ratio.

$$ETX = \frac{1}{d_f \times d_r} \qquad (4)$$

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Implementation setup

An extension validation of the simulation outcome is carried out for ensuring the goodness of the introduced D2FS model in MANET with respect to several dimensions. The simulation parameters involved in this study is tabulated in Table 1.

Table 1 Parameter Settings

Parameter	Value
Tool	NS2.35
Node count	100
Region size	1000x1000m^2
Transmission radius	250m
CBR data rate	24 Mbs^{-1}
Time gap of hello packets	1s
Mobility speed	5-25 ms^{-1}
Traffic category	CBR
Radio category	802.11 a/g

Next, a collection of validation parameters are applied for the investigation of the performance are packet delivery ratio (PDR), routing overhead, overhead, end to end (ETE) delay and routing load. To compare the results of the presented model, 3 models are employed namely AODV, CBF2S and LORA_CBF.

3.2. Results analysis

Fig. 4 demonstrates the near investigation of different routing models with respect to diverse hop count in terms of routing overhead. From the compared strategies, the technique AODV shows worse results with respect to routing overhead as the quantity of hop count gets increased. At the point, when there are no transitional mobile nodes, the routing overhead achieved by AODV is 25K packets. The LORA_CBF technique accomplishes pretty much the equivalent routing overhead rate. Simultaneously, for a similar hop count, the CBF2S model shows manageable results with the low routing overhead of 12K packets. However, the presented model contains the routing overhead of just 10.5K packets. For instance, when the hop count is equivalent to three, the AODV accomplishes again the most exceedingly bad performance by accomplishing the higher routing overhead of 34K packets. The LORA_CBF does not indicate noteworthy outcomes. The CBF2S model tries to show reduced routing overhead with the 12.5 K packets of routing overhead. But, the proposed technique thus accomplishes the most reduced routing overhead of 10.8K packets as same as which it has shown when there are no intermittent nodes. At the point when hop count is seven, the AODV strategy achieves the most extreme routing overhead of 41 K packets. The LORA_CBF to some degree keeps up to exhibit the equivalent routing overhead, it comes up short regarding proposed strategy that achieves insignificant routing overhead of 11.6K packets. Though the CBF2S method showed somewhat moderate results with the routing overhead of 13.5K packets, it is not lower than the presented method. In this manner, even the hop count gets increased, the proposed strategy withstand with the equivalent routing overhead and consequently displaying better execution over others.

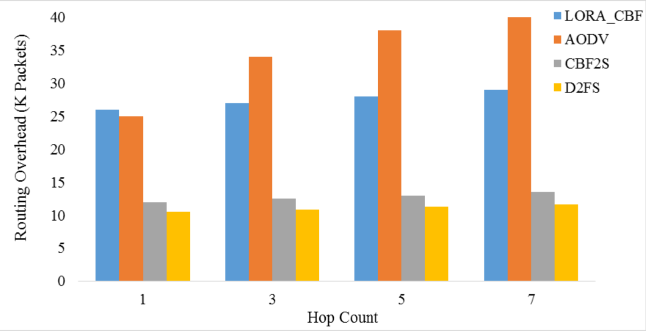

Figure 4. Comparative analysis interms of routing overhead under varying hop count

Fig. 5 exhibits the relative consequences of various routing models under changing hop counts interms of overhead. Over the analyzed strategies, the strategy AODV and LORA_CBF shows poor results all in all by methods for overhead as the quantity of middle of the road hub increments. At the point when the hop count is 1, the overhead acquired by AODV and LORA_CBF is 100 packets. Under a similar hop count, the CBF2S and proposed strategy involves just 99 and 97 packets. For three hop counts, the AODV and LORA_CBF accomplishes again most exceedingly terrible and same execution rate by accomplishing the higher overhead of 99 packets. The earlier CBF2S model shows moderate results with the low overhead of 97 packets. However, the proposed technique thusly achieves the least overhead of 95 packets. At the point when hop count is seven, the AODV technique accomplishes the most extreme overhead of 99 packets. The LORA_CBF achieves 97 as overhead; it flops over the proposed strategy that accomplishes insignificant overhead of 92 packets. In this manner, even the quantity of hop count builds, the proposed technique indicates most reduced overhead, subsequently showing proficient execution when contrasting with others.

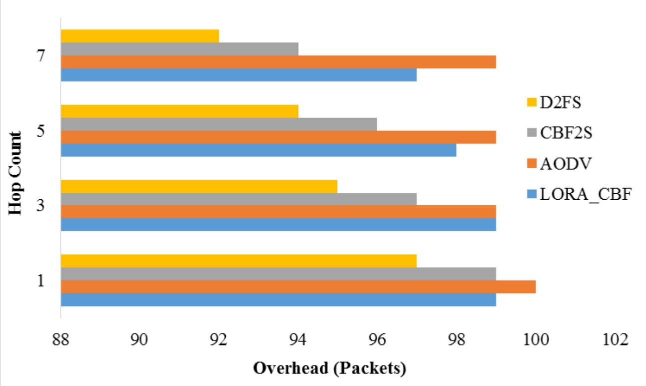

Figure 5. Comparative analysis interms of overhead under varying hop count

Fig. 6 demonstrates the similar examination of different routing methods under changing hop counts interms of ETE delay. On comparing the various models, the technique AODV exhibits poor results by methods for ETE delay as the quantity of hop count upgrades. At the point when there are no halfway nodes, the ETE delay accomplished by AODV is 16ms. The LORA_CBF technique accomplishes pretty much the equivalent ETE delay rate. For a similar hop count, the CBF2S attains a slightly lower ETE delay of 20ms whereas the proposed technique takes a sum of 17ms. When the hop count is equivalent to three, the AODV accomplishes again worse results by accomplishing the higher ETE delay of 65ms. The LORA_CBF and CBF2S thusly achieve the most reduced and same ETE delay of 55 ms as same as which it has displayed when there are no middle nodes. In the same way, the presented model achieves minimum ETE delay of only 49ms. At the point, when hop count is seven, the AODV strategy achieves the greatest ETE delay of 152ms. The LORA_CBF to some degree keeps up to show the ETE delay of 133ms, it fails to show better results concerning proposed technique that accomplishes negligible ETE delay of 110ms. In this manner, despite the fact that, the quantity of intermittent node increases, the proposed strategy opposes with the comparable ETE delay, in this way displaying better execution over others.

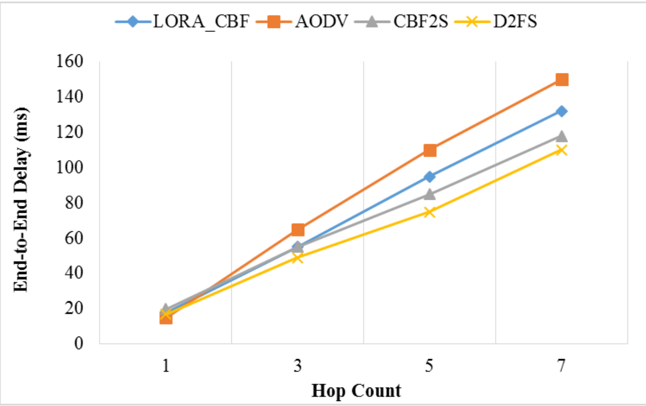

Fig. 6. Comparative analysis interms of end to end delay under varying hop count

Fig. 7 exhibits the comparison results of various models under shifting hop counts based on routing load. Over the analyzed procedures, the technique AODV and LORA_CBF show poor results over other methods for routing load as the quantity of hop count gets incremented. At the point when the hop count is 1, the routing burden gotten by AODV and LORA_CBF is 250packets. Under the nearness of same hop count, the proposed technique includes just 115 packets. For hop count is equivalent to three, the AODV accomplishes again the most noticeably awful exhibition rate by accomplishing the higher routing load of 500 packets. The LORA_CBF keeps up to shows equivalent to the past range; however, it neglects to succeed the proposed strategy. Thus, it accomplishes the most minimal routing load of 132 packets over the other methods.

At the point when hop count is seven, the AODV technique achieves the maximum routing load of 1060 packets. The LORA_CBF accomplishes higher routing load of 275 packets whereas the CBF2S also attained slightly lower routing load of 180 packets. At the same time, the proposed technique achieves negligible routing load of 165 packets. Hence, despite the fact that, the quantity of hop count increases, the proposed strategy indicates most minimal routing load, in this manner, displaying effective presentation when contrast with the other methods.

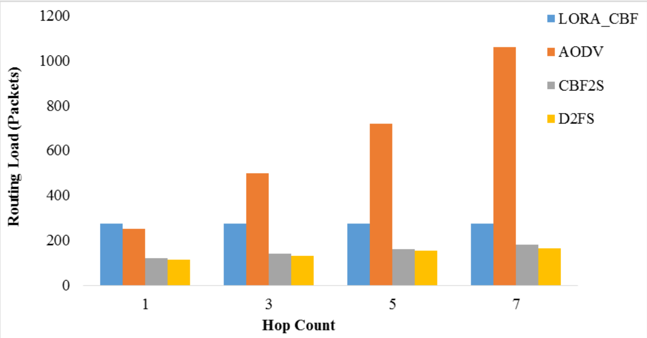

Fig. 7. Comparative analysis interms of routing load under varying hop count

Fig. 8 shows the relative investigation of different methods under changing hop counts as far as PDR. In general, the proposed strategy accomplishes the higher PDR even the intermittent rate gets increased. For the hop count equals to 1, the AODV technique is the poor entertainer which accomplishes diminished PDR of 97, while the LORA_CBF, CBF2S and proposed strategy achieves pretty much the comparable PDR of 100. For the hop count that is equivalent to 3, AODV achieves the lower PDR rate of 69 and the LORA_CBF gains PDR pace of 83. The proposed technique accomplishes the equivalent maximum PDR rate 100. For the hop count 7, minimum PDR rate is acquired through AODV by accomplishing PDR rate of 38 while the LORA_CBF achieves 74 as PDR rate. Indeed, even through the hop count improves, the maximum PDR rate of 100 is delineated by the proposed model. Under all the applied cases, the proposed technique is effective compared to other models under several dimensions.

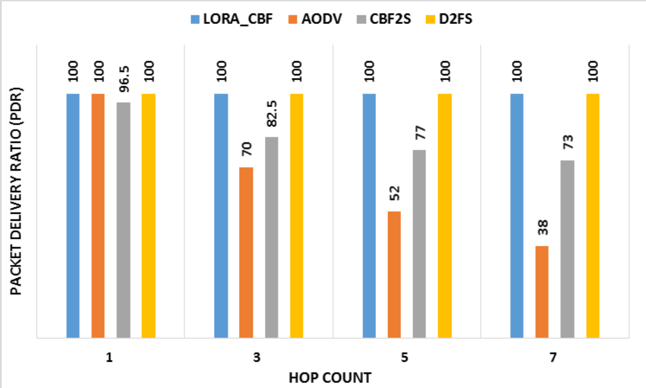

Fig. 8. Comparative analysis interms of routing load under varying hop count

IV. CONCLUSION

Flooding is commonly used for broadcasting purpose in MANET. Cluster based Flooding is an important issue in the design of MANET where it is an order to manage data traffic as it utilizes a set of chosen nodes to transmit data between two nodes. At first, CBF2S model is connected for the association of versatile nodes in MANET into clusters. At the same time, an essential process of selecting forwarding set in the inter-cluster flooding. To select the effective forwarding set in MANET, in this paper, D2FS model is introduced. An extension validation of the simulation outcome is carried out for ensuring the goodness of the introduced D^2FS model in MANET with respect to several dimensions. The experimental outcome pointed out that the presented D2FS model is superior to other models on all the applied scenarios.

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