A Novel Broadcast Scheme DSR-based for Mobile Ad hoc Networks

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***Abstract*—Traffic classification aims at assigning packet flows to adequate Quality of Service (QoS) aware transmission. Although a great deal of research was conducted on broadcast communication in ad-hoc networks, broadcasting is still a challenging issue. Although blind flooding is considered as the most well-known broadcasting mechanism, it is inefficient in terms of communication and resource utilization. Alternatively, the counter based broadcast scheme is one of the diversified efficacious schemes to alleviate blind flooding scarcity where it counts, on the received redundant packet number over the node and its neighbours, whereas the node contrasts the redundant packet itself as well as each neighbour node which has already rebroadcasted a packet. Currently, the existing counter-based schemes are mostly based on a fixed counter based approach. However, these schemes cannot perform efficiently in various operating conditions. Thus, unlike existing solutions, this paper suggests a dynamic counter-based threshold value and investigates its effectiveness within the renowned reactive routing protocols, namely, Dynamic Source Routing Protocol (DSR). Precisely, we develop a novel broadcasting counter-based algorithm, namely Inspired Counter-Based Broadcasting (DSR-ICB). DSR-ICB, through diversified simulation experiments, has demonstrated superior performance especially in terms of delay as well as redundant packets rate.**

Keywords—MANETs; Traffic classification; Broadcasting; DSR; Dynamic Counter based

I. Introduction

The Mobile Ad-hoc Networks (MANET) is known as self-configuring as well as an infrastructure-less network. The main component of this network is the small freely movement devices such as mobiles that are often referred as nodes. These mobile nodes are linked together through wireless media and have the ability of freely moving in any random way or direction. As a result, MANET links are frequently changed from some nodes to some others due to its dynamic topology. Moreover, it aims at facilitating that kind of applications which do not need any pre-established networking infrastructure. The catastrophe applications, smart city applications, the air force applications, the contingency, and the communion application are key fields where MANETs are deployed [1, 2].

MANETs are characterizing be some features that make them a good choice in several cases and scenarios. However, these features demonstrate key challenges as well as problems with the enormous dissemination of MANETs. The most leading features and provocations of MANETs are abbreviated as follows: the infrastructure-less features, the mobility feature, the energy conservation feature, the multi-hop routing feature, the self-organizing feature and the bandwidth-constrained future. In addition, many provocations that require being prevailed over, such as the transmission range, the overhead of routing and the bandwidth restrictions [3, 4].

Mainly, the primary practicability in MANETs is broadcasting by which all nodes within the network receive the same message that was sent or transmitted by the source node. At the one-to-all communication pattern, every node transmission reaches all network nodes that reside within the node transmission range. However, a lot of considerable applications as well as sundry ad-hoc network protocols that belong to broadcasting operation always assume the existence of an available underline broadcast feature [5]. In reactive protocols, the route discovery application is the most application that gain advantages from the broadcast communication. To illustrate, some ad-hoc routing protocols such as Dynamic Source Routing (DSR) [6] depend on using the simple flooding or broadcasting for the purpose of establishing routes that result in the well-known broadcast storm problem. To avoid this problem, efficacious broadcast algorithms can be deployed with a view to reduce the number of nodes that re-transmit the broadcast message once it ensures that the packet has been received by all nodes. In the purpose of reducing rebroadcasts count, the counter based method can be properly used in broadcasting as it minimizes the possibility of having contentions as well as collisions between neighboring nodes. Encouraged by these perceptions, this work will concentrate on the DSR protocol performance that is mainly employed in MANET, influenced by the Inspired Counter Based Broadcasting (DSR-ICB).

DSR is an on-demand routing protocol in which all data packets have the whole routing information about the nodes to reach the destination. To maintain routing information, each node in DSR counts on caching technology and each node updates its route caches when a new route is established. DSR routing has two phases; the first is route discovery and the second is route maintenance. Whenever a node needs to transmit a data packet to another node (destination), it first searches its own route cache to check whether it has a route to that node or not. If a route to that node is saved, then it is used to transmit the data packet to the destination. Otherwise, the route discovery phase must be started by a broadcast route request packet that uses blind flooding. The route request message always has the source address, destination address as well as a unique identifier number. In addition to each intermediate node examines if it has a route to the destination or not. In case that it does not have a route to the destination, it updates its own address to the packet route record as well as forwards it to its neighbors. The second phase takes place just when the source node route record does not contain the address as well if it has not seen the packet before. This algorithm presents a large dilution in the number of unnecessary multiplied re-broadcast packets with also perfect results pertaining to the re-broadcast saved packet numbers, the reachability of the packets, the latency, and others. Qualnet simulator was adopted also to compare the counter based schemes in this work [7]. This paper is formatted as follows: In Section II, literature work of MANETs broadcasting is revised , Section III shows the new DSR-5C algorithm, Section IV the results gained from our simulation as well the DSR-5C scheme is characterized. At the end, Section V contains the conclusion.

II. Related Work

In MANETs, there is no restriction on any node with regard to broadcasting the packet at any time, as well as no acknowledgment is used when the packet is received. Due to node mobility in MANETs, it is expected that broadcasting will be accomplished more repeatedly to carry out substantial functions such as establishing and detecting a route to an appointed node [2, 3]. In a particular geographical area, some radio signals have a potential chance to overlap with other radio signals. In this case, simple flooding or a straight forward broadcasting is always costly as well as causes the broadcast storm problem. In [5, 8], authors have presented distinct schemes to minimize repeated rebroadcasts as well to disperse rebroadcasts timing to relieve this trouble. Broadcast schemes have been classified by Williams and Camp [9] into four broad classes; the probability-based schemes, the distance-based schemes, the cluster-based schemes, as well as the counter-based schemes.

BaniYassein et al. [10] suggested a new adjusted dynamic probabilistic approach that improves the probability-based scheme through adapting a dynamic broadcast probability P that depends on the neighbors number and is considered as an indicator of the density of the node. In order to get information about one-hop neighbor numbers, this approach propagated a periodic short "Hello" packets. The probability of receiving redundant packets in a dense area is very high. Hence, probability P must have a low value to avoid redundant packets. Furthermore, a high probability value should be assigned in a sparse area in order to ensure that a maximum number of destinations have received the packets. It is topically unvarying characteristic in which all nodes have a fixed probability to achieve reachability as well as each node receives a broadcasting packet [4, 11].

Broadcast algorithms have been suggested by sundry research studies [12, 13] that mainly have architectures that depend on clusters as a trend for improving broadcasting thoroughness. Such studies use one cluster head for each cluster whereas its job is to dominate the other members within the same cluster as well to compute locally its forward node set. Hence, there is an essential need to make a load-balancing between nodes by distributing the cluster head responsibility among all nodes. Although load-balancing algorithms expected to have routing problems in MANETs, but no serious endeavor has heretofore been accomplished to drive such schemes into the broadcasting scene. Authors in [9] used rapidity percipient probabilistic-route-discovery paradigms so they have the ability to eliminate the uneasy nodes through establishing routes among source node as well as its destination. Bani Yassein et al. [15] presented a probabilistic distance, using the fuzzy logic. In this study, a broadcasting scheme depends on fuzzy logic at each node for the purpose of dynamically setting a probability value according to the node location. Four main locations were used to classify the node location that are (border, internal border, exterior, and interior), each location has a probability value , specifically, high, medium, low, as well as very low. The results of Bani Yassein et al. [15] have shown that using fuzzy logic control scheme has a better enhancement than using probabilistic scheme, resulting in higher saved throughput and saved re-broadcast. However, assigning a higher probability always to the border is not correct for all the cases and this was the main drawback of [15].

Zhang et al. [14] presented an adoption technique for broadcasting. This adoption scheme mainly depends on RTS/CTS frames at MAC layer. However, the exposed station problem may occur when using RTS/CTS frames. Authors in [12] presented a local broadcast algorithm that aims at reducing transmissions number. Regrettably, this algorithm depends on a static method, hence, it indicates that calculating the minimum connected dominating set has the problem of the NP-complete algorithm . Bani Yassein et al [16-18] suggested a novel counter-based algorithm for broadcasting solutions that aims at gaining an effective packet transmission with a high delivery ratio, minimum delay rate and minimum network overhead. This novel scheme exceeds the performance of both counter-based as well as the simple flooding through providing three counters. This scheme also avoids the "brute force" problem which drains the resources of the network and causes a very high overhead. Nevertheless, the suggested scheme gives further dynamic as well efficacious result when further counters have been added to it instead of three values.

In an attempt to fill in this gap, our algorithm preserves additional superior performance comparing with existing counter-based schemes in terms of diversified metrics. In additopn, our scheme gives additional efficacious as well as a dynamic result if it has more than four counter values. Our suggested algorithm was developed beneath AODV reactive routing protocol as well as the highly adjusted counter-based scheme will be used within DSR.

III. The Proposed Scheme

From the above observations, this paper aims at suggesting a more efficient broadcast scheme, in which the received redundant packets number can be considered and examined. The incremented counter as deducted from the related work was used in many Ad-hoc broadcast algorithms where a one is added if a broadcast multiplied message arrives at the node itself. Simultaneously, a threshold number was also used in literature that is, in some studies, fixed and in others are dynamic. Thus, the node totally depends on the pre-fixed threshold number to re-broadcasting messages. Furthermore, an ingenious counter based algorithm for broadcasting can be destined to fulfill the goal of re-broadcasting in Ad-hoc. It aims at increasing the reachability hits by reducing multiplied re-broadcast packets received at the network nodes. Initialization of a counter c is the core idea of the Counter-based adaptive broadcasting scheme. This counter aims to track besides count the received packets number.

Depending on the status of the node neighboring, another threshold counter was created. Counting on the density, five general thresholds were created in a way that takes into account where the nodes reside. For instance, nodes that exist in the dense zone get a distinct threshold rather than those nodes resides in extra dense, medium, or sparse zone within the network. Hence, the sparse zone has threshold_1 value, the medium zone has threshold_2, the dense zone has threshold_3 and the extra dense zone has threshold_4 value. The above threshold numbers must be determined with respect to the information of nodes' neighbors. Then counter c will be compared with one of these threshold numbers, whereas c is the counter of duplicated packets that have received. Broadcasting process will keep on as long the counter c has a value less than the threshold number. The way that the proposed algorithm is performed in can be described as follows: at first, when node X listens a broadcasted packet m, the node checks if it received for the first time, then it rebroadcast packet m considering node density as the following description in which threshold_1, threshold_2, threshold_3, threshold_4 and threshold_5 are predefined numbers and threshold_1< threshold_2 < threshold_3< threshold_4< threshold_5. At first, if the node resides in the sparse zone, then node X re-broadcasts the packet conforming to threshold_1, whereas the sparse zone refers as the zone in which the average minimum number of neighbor's avg_neighbors_1 is greater than the number of neighbors. Secondly, node X depends on threshold_2 when the location of X resides in the medium zone that indicates that the number of neighbors of node X is larger than the avg_neighbors_1 minimum number. Also, it must be lower than or equal to the avg_neighbors_2 the maximum number of neighbors. Thirdly, if the node X resides at the dense zone then it depends on threshold_3 that illustrates node X neighbors has a larger number than avg_neighbors_2 (the maximum neighbors number) and must be lower or equal the avg_neighbors_3 that is the extra maximum neighbors number. At the end, threshold_4 is the reference in node X broadcasting whenever it is in the dense zone and its neighbor's number is higher or the same as avg_neighbors_3 (the extra maximum neighbors numbers).

This section presents the evaluation of the DSR-ICB or DSR-5C performance. DSR-5C algorithm, in general, may be deployed in any broadcast function. This function spreads the route requests (RREQ) through the on-demand routing protocols route discovery process. This function also in order to discover the destination route implies that RREQ has to reach all nodes that have a route to the desirable node.

We developed ICB in a way that it can decide which nodes that must broadcast a route request (RREQ) packets in DSR route-discovery operation. By this way, thus we can study the effect of ICB on DSR route-discovery operation. Moreover, the obtained protocol was given the name of DSR-5C or DSR-ICB as well as we fully implemented it in Qualnet [7].

Algorithm 1: Inspired Counter Based Broadcasting: (DSR-ICB) or (DSR-5C).

```
Input  : BROADCAST MESSAGE (MSG)
Output: DECIDE WHETHER TO REBROADCAST MSG OR Get the
        broadcast ID from the packet; n1 minimum numbers of
        neighbour; n2 Medium number of neighbour and n3 maximum
        number of neighbour, n4 extra maximum n5 Ultra extra
        maximum number of neighbour
ON HEARING A BROADCAST PACKET AT NODE X
Get degree n of node X
if n < n1 then
    Node X has a low degree: the low threshold value
    (threshold=c1);
end
else if n > n1 and n ≤ n2 then
    Node X has a medium degree: the medium
    threshold value (threshold=c2);
end
else if n > n2 and n ≤ n3 then
    Node X has a high degree: the high threshold value (threshold = c3) ;
end
else if n > n3 and n ≤n4 then
    Node X has a very high degree: the high threshold value
    (threshold=c4);
end
else if n > n4 and n ≤ n5 then
    Node X has Ultra degree: the high threshold value
    (threshold=c5)
end
while not hearing a message do
    Wait for a random number of slots.;
    Submit the packet for transmission and wait until the transmission
    actually start;
    Increment c
end
if c < threshold then
    Submit the packet for rebroadcast
end
else
    Drop the packet from rebroadcast
end
```

Fig. 1. Inspired Counter Based Broadcasting

Traffic as well as mobility models that are comparable with those that formerly discussed for DSR performance [6] have been used for the reason of comparing both the DSR-5C and DSR-F (DSR with flooding). Mainly, three versions of DSR were used in order to address reliability. The first version was implementing DSR with ICB (DSR-5C) or (DSR-ICB) which presented in Figure. 1. The second version was implemented with an adjusted counter based (DSR-4C) [17, 8] and the third version was with flooding (DSR- F) [6].

IV. Simulation Results and Analysis

In this study, we have used Qualnet simulator that is a well-known discrete-event simulator, which has been expanded to backing mobile wireless (as well Ad-hoc) operations and simulations [7]. We repeated the experiments for 20 attempts with diversified random-number seed, as well as traffic endpoints. Consequently, we compare all protocols that have identical node mobility as well as traffic needs. Each point of the data presents the mean of the 20 attempts. In our counter based algorithm, it is worth pointing that there is a tiny chance that the route request may not arrive the destination. Hence, the route request has been generated again if prior RREQ fiasco to arrive at the desired node (destination). Conversely, DSR commonly employs flooding at route discovery operation. Hence, if the network is not disconnected or partitioned, then all route requests will arrive at their destinations. Depending on this analysis, this proposed algorithm has to have a better performance than DSR-F as well as DSR-4C in dense area networks that have intensive traffic [17, 8].

In simulations, two distinct nodes were chosen as a data sources. A CBR traffic generator has been attached to the sources. Random waypoint model from the mobility models was chosen because it is the most suitable model for MANETs environments. Furthermore, we used 50 nodes and place them in a random way on a 1000m x 1000m region with a 2M bandwidth.

1) Effects traffic loads

In order to discover the impact of traffic loads, generally we use diversified traffic loads such as light, moderate, and intensive traffic. In order to achieve this, the following broadcast packets rates have been produced at the source node and have been examined:

- Light traffic load: 1 packets/sec;
- Medium traffic load: 5 packets/sec;
- Heavy traffic load: 11 packets/sec;

The broadcast latency was measured using three approaches. The start time of broadcast was recorded besides the time at which the broadcast packet reaches the last node. Hence, the broadcast latency was calculated by finding the difference between these two values. Because packet rebroadcasts may collide as well as content with each other within the same channel, counter-based method undertakes the minimum rebroadcasts number. It must have the minimum latency, which is mainly influenced by total packets number that is transmitted in the channel. Therefore, the number of collisions depends on the packets number, whereas if packets number is high, then collisions in the channel are high and thence more retransmissions are required. Later, as a result, lower delays can be gained with fewer packets. Figure 2 presents the end-to-end delay to the diversified traffic loads. As predicted, the DSR-5C exhibits minimum latency than both DSR-F as well as DSR-4C. Figure.3 explicates DSR-5C algorithm which has the ability to successfully minimize the re-broadcasts number for a 50 nodes network, each with maximum speed of 1 m/s. When traffic load grows, Figure 3 shows that route requests re-broadcast number increases. Figure. 4 portrays that as network traffic load increases, reachability increases regardless of the type of algorithm is used. With regards to reachability, reaching nearly 1, DSR-5C algorithm has the best performance. The performance of DSR-4C indicates that reachability is higher than 95% within traffic load identical to 10.

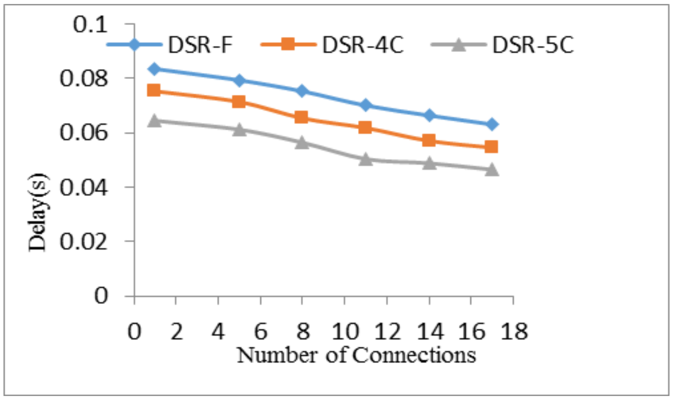

Fig. 2. End To End Delay Vs. Connections Number

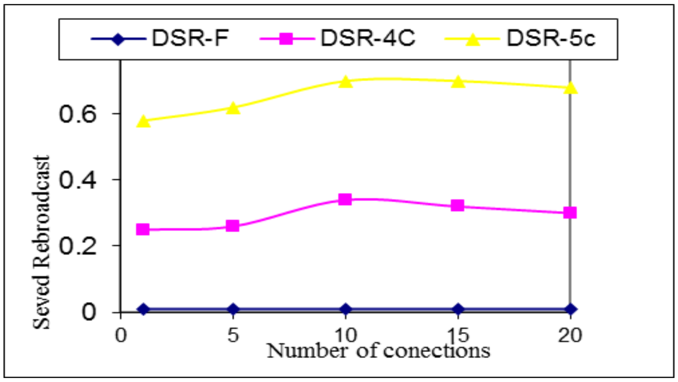

Fig. 3. Saved Re-broadcast vs. Connections Number

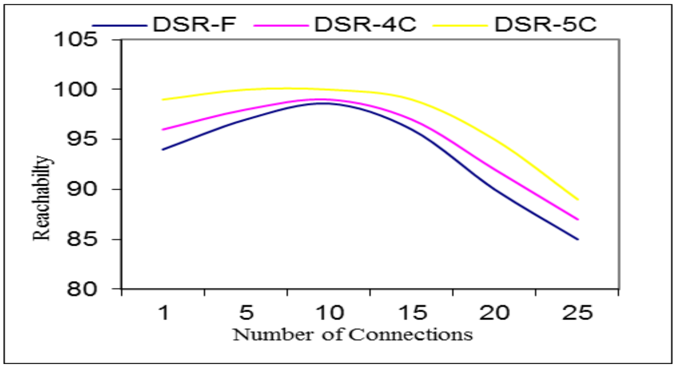

Fig. 4. Reachability vs. Connections Number

As well, in Figure. 5, packet delivery ratio was compared to diversified traffic loads. Figure 5 presents that as the connections number raises, the packet delivery ratio decreases. The packet delivery rates descend because of the reality that destination or intermediate nodes movement may incur route expiration as well route request re-transmission. Figure 5 also demonstrates that DSR-5C performs better than DSR-4C besides DSR-F. As discussed before, the main reason for the DSR-5C packet delivery ratio improvement is because of its reduction of rebroadcasting. Figure 6 explains that routing overhead raises as traffic load raises. When more connections are established, then the more route requests that cause more rebroadcasts, higher routing overhead as well as higher bandwidth consumption. Figure 6 also presented that DSR-5C outperforms DSR-F, DSR-4C by about 20%.

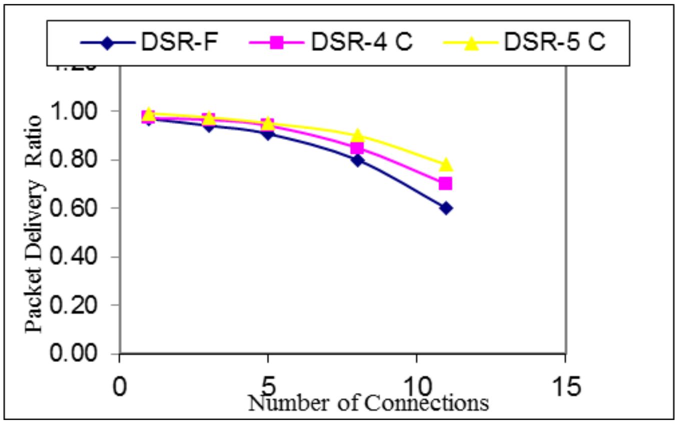

Fig. 5. Packet Delivery Ratio vs. Connections Number

2) Effects of node Speed

In our experiments, we aim to investigate the influence of the node speed on the examined protocols performance using 50 nodes. In these experiment scenarios, maximum node speed range is from 1m/s up to 20 m/s. The network is sparse when the number of nodes is 25 nodes as well as it is dense when the number of nodes is 100 nodes.

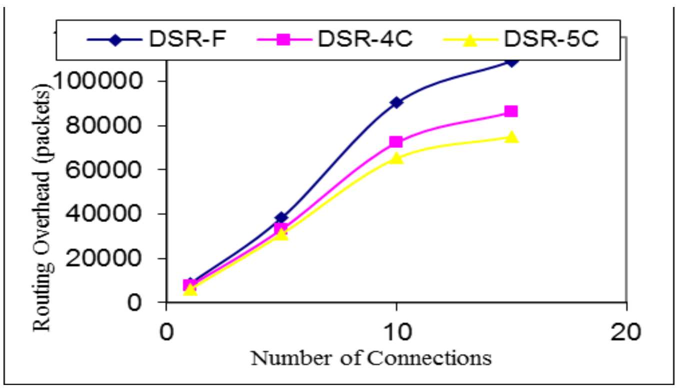

Fig. 6. Routing Overhead vs. Connections Number

Figure 7 presents the average end-to-end delay for the three schemes evaluated at different node speeds. It reveals that when the node speed increases, the delay is also growing. This is because that whenever the node speed increases, there are more generated data packets competing for the limited buffer space. As a result, more queuing and buffer overhead is experienced, resulting in higher delay in addition to the higher node speed, which affects the stability of the network. That is why the network could have more breakage links and therefore failure in delivering the packet to the destination. This will result in generating extra RREQ and exhibiting growing end-to-end delay. The new proposed scheme outperforms the other schemes in terms of the average delay by 66% compared with blind flooding and 35% compared with three counter-based scheme for all node speeds.

Figure 8 presents delivery ratio for the three examined schemes against different node speeds. Figure.8 shows that whenever the node speed increases the PDR decreases because the more speed generated the less stable network links.

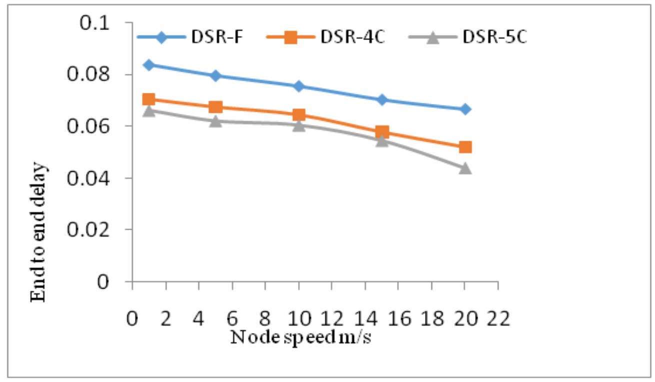

Fig. 7. Average end-to-end delay vs. Node Speed

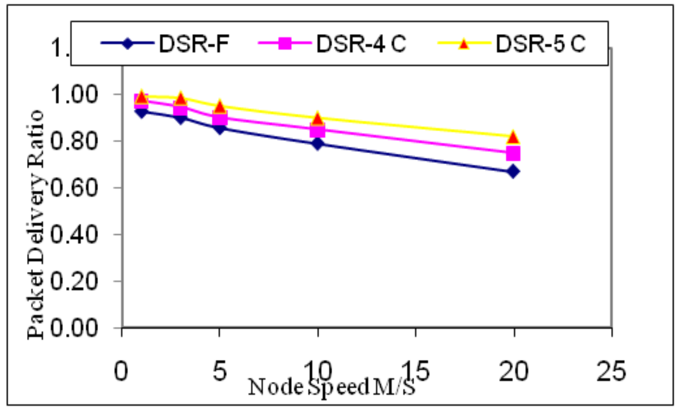

Fig. 8. Packet delivery ratio vs. Node Speed

From Figure 8, it appears that our proposed algorithm conserves nearly the same performance level which gained from the formerly examined schemes with varying node speeds. Figure. 9 illustrates that DSR-5C algorithm can appreciably minimize the re-broadcasts number in a 50 nodes network as well as various node speeds = 1, 5, 10 and 20 m/s.

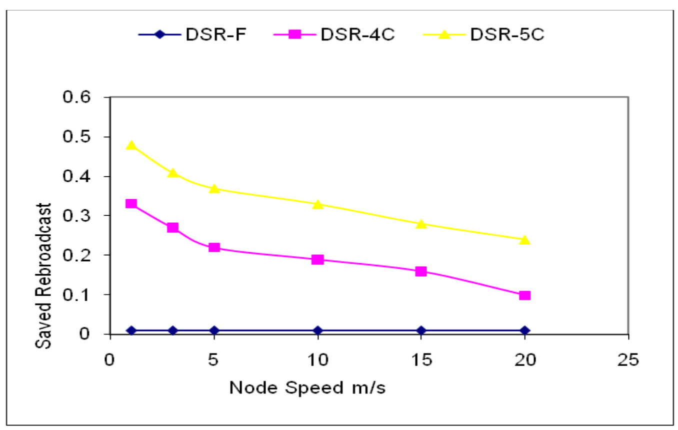

Fig. 9. Saved Rebroadcast vs. Node Speed

Furthermore, our algorithm shows its superiority over DSR-F and DSR-4C for all speed values in terms of packet delivery ratio. We can conclude from the results that our protocol maintains the high level of enhancement over the other two protocols DSR-F and DSR-4C despite the number of nodes involved. The results of the end to end delay show how our protocol exceeds the two other protocols DSR-F and DSR-4C for all speed values.

V. Conclusion

In this paper, a new dynamic counter based route discovery scheme has been presented for MANETs. Diversified simulation experiments have been examined to test our proposed algorithm beneath varied operating conditions. The results concluded that the new dynamic counter based broadcasting scheme overcomes the limitations of the other evaluated schemes in terms of mitigating the broadcast storm problem, redundant packets transmission, collision, and contention. In addition, the proposed scheme achieves high packets delivery ratio with a reduced level of delay while keeping the routing overhead to a minimum. As an attempt to enhance the route discovery operation within reactive routing protocols, we developed novel suggested counter based algorithm within DSR namely DSR-5C. Moreover, the results confirm that DSR-5C enhances the performance of DSR, in all aspects and in traffic load scenarios.

In addition, we also present DSR performance with flooding that depends on adjusted as well as fixed counter based considering various working situations. The conducted performance analysis implied that latency characteristics within DSR-5C algorithm higher than those in DSR common algorithms such as in DSR-f. Another critical result shows that DSR-5C algorithm performance grows reasonably while the saved re-broadcasts are growing. The dynamic counter-based broadcasting finds a solution to the challenging problem of route discovery in MANETs. However, there are still several interesting issues and unsolved problems that require further investigation. As a next step, we are willing to investigate the effect of the proposed approach with a broad range of routing protocols and different mobility models such as Manhattan Model, Trace-based Models, and Pathway model. Besides, we aim to explore the correlation between the rebroadcast probability and the counter between mobile nodes. Moreover, we will also develop a hybrid approach that combines the features of both counters based and distance based schemes. It is anticipated that this direction will enable us to explore fully the routing discovery challenging issues and present efficient solutions accordingly

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