Inspired Counter Based Broadcasting in Dynamic Source Routing Protocol

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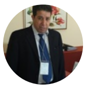

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Inspired Counter Based Broadcasting for Dynamic Source Routing in Mobile Networks

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Abstract— The broadcast storm problem is one of the most challenging issues in Mobile ad Hoc Networks (MANETs). However, it is still a challenging problem despite the great deal of related works and existing solutions. Dynamic Source Routing Protocol (DSR) is one of the well-known on-demand routing protocols that has been widely studied and analyzed over the past few years. However, there is a lack of methods and solutions for the broadcast storm problem in DSR under the umbrella of dynamic operating conditions. Thus, to improve the routing discovery process in DSR we incorporate a new counter based broadcast algorithm in DSR, namely, Inspired Counter Based Broadcasting (DSR-ICB). The new variants are based on the counter based approach which reduces the number of redundant packets. Simulation experiments have been conducted in different scenarios. The results illustrate that the proposed algorithm has significantly improved the DSR in terms of a number of important metrics such as saved rebroadcasts, reachability, end-to-end latency, packet delivery ratio.

Keywords— MANETs; Broadcast; Flooding; Counter-based; Broadcast storm problem; Reachability; Delivery ratio.

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is an infrastructure-less and self-configuring network that consists of mobile devices which are connected by wireless links. In MANETs, each node is able to move freely and randomly in any direction. Thus, it frequently changes its links to the other nodes. MANETs can facilitate applications that require nodes to communicate without depending on a specific infrastructure, such as those used for crisis-management application, emergency, military application, group and collaboration communication and personal network [1-2].

MANETs are distinguished by a number of characteristics that make them one of the desired networked systems technologies. However, these features pose several challenges and problems to the vast deployment of MANETs. The most important characteristics and challenges of MANETs are summarized as follows infrastructure-less, mobility, energy conservation, multi-hop routing, self-organization and bandwidth-constrained. On the other hand, many challenges that need to be overcome such as transmission range and bandwidth limitations and routing overhead [3-4].

Broadcasting is a fundamental operation in ad hoc networks whereby a source node sends the same packet to all the nodes in the network. In the one-to-all communication pattern, the transmission by each node can reach all nodes that are within its transmission radius. Broadcasting has many important applications and several ad hoc network protocols assume the availability of an underlying broadcast service [13]. The route discovery in reactive protocols is one if the applications that benefit from the broadcast communication. For instance, a number of MANET routing protocols such as Dynamic Source Routing (DSR) [8] use broadcasting or simple flooding as one of its derivatives to establish routes that causes the broadcast storm problem. The broadcast storm problem can be avoided by deploying efficient broadcast algorithms that aim to reduce the number of nodes that retransmit the broadcast packet and guaranteeing, at the same time, that all nodes receive the packet. Proper use of a counter based broadcasting method can reduce the number of rebroadcasts, and as a result reduces the chance of contention and collision among neighbouring nodes. Motivated by these observations, this study will focus on the performance of DSR routing protocol used in MANET using proper counter based schema algorithm called Inspired Counter Based Broadcasting (DSR-ICB).

DSR is a source-routed reactive routing protocol in which each data packet has complete routing information to reach the destination and each node uses caching technology to maintain routing information. When a new route is created the node updates its rout caches. It works on two phases, namely, route discovery and route maintenance. When the source node wants to send a packet to a destination, it search in the node's route cache to see if it is already has got a route to the destination. If it exists then it uses that route to send the packet. However, if is not the case, it starts its route discovery phase by broadcasting a route request packet using blind flooding. That contains the address of the source, destination, and a unique id number. Each intermediate node checks whether it has a route to the destination. If not, it adds its address to the route record of the packet and forwards the packet to its neighbors. The route request is performed only if the node has not seen the packet before and its address does not exist in the route record of the packet using a new counter-based broadcast algorithm present a major cut of the number of redundant rebroadcast packets along with good results in terms of reachability, saved rebroadcasts, latency, packet delivery ratio and routing overhead and an extensive comparison against exiting counter based schemes have been performed using Qualnet simulator [11].

The rest of this paper is organized as follows. Section 2, Literature review of broadcasting in MANET is overviewed, Section 3, presents the new algorithm proposed of a counter based broadcast scheme, Section 4 the obtained simulation results and analysis of the proposed scheme are described. Finally, Section 5 concludes this study.

II. LITERATURE REVIEW

Broadcasting is a key operation for discovering neighbour nodes in the network. In MANETs, any node can broadcast the packet at any time, and there is no acknowledgment for receiving that packet. In MANET, due to node mobility, broadcasting is expected to be executed more frequently to perform essential operations such as finding a route to a particular node [2, 3]. Because radio signals are likely to overlap with others in a given geographical area, a straight forward broadcast by flooding is usually expensive and results in the broadcast storm problem.

In [13, 15], they have proposed several schemes to reduce redundant rebroadcasts and differentiate timing of rebroadcasts to alleviate this problem. Williams and Camp [14] have classified the broadcast protocols into: simple flooding, probability based schemes, counter-based schemes, distance based, location-based schemes and neighbor knowledge schemes.

Bani Yassein et al [5] have proposed a probabilistic scheme where the probability *p* is computed from the local density *n* to achieve reachability of the broadcast. However, this scheme has the disadvantage of being “locally uniform” in that each node of a given area receives a broadcast and determines the probability according to a static efficiency parameter to achieve the reachability as well as from its local density [4, 16].

Several research studies have suggested broadcast algorithms [6, 10] that are based on the clustered architecture as a way to improve broadcasting reliability. In these algorithms, each cluster has one cluster head that dominates all other members in the cluster and computes its own forward node set locally. Therefore, there is a need to distribute the responsibility of being a cluster head to all nodes (load-balancing). While the load-balancing algorithms have anticipated for the routing problem in mobile ad-hoc network, no attempt has so far been made to introduce such algorithms within the context of broadcasting.

Bani Khalaf et al. [14] have used velocity aware probabilistic route discovery models to exclude unstable nodes while constructing routes between the source and its destination.

Ni et al. [9] proposed an adoption broadcast technique which based on the RTS/CTS frames at the MAC level, however using RTS/CTS frames will affect the exposed station problem.

In [6] authors have proposed a local broadcast algorithm to reduce the number of transmissions. Unfortunately, however, the local broadcast algorithms are based on static approach and it is worth indicating that finding the minimum connected dominating set is an NP-complete in this type of algorithms.

Bani Yassein, et al [7], have proposed a counter based solution that can achieve a higher degree of reachability. This scheme enable the nodes to rebroadcast the message only if the number of received duplicate packets is less than a threshold value by taking into account the node density either in dense or sparse areas.

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ALGORITHM: 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);
   Else if  n> n1 and  n≤ n2 then
        Node X has a medium degree: the medium
        threshold value (threshold=c2);
   Else If  n> n2 and n≤ n3 then
        Node X  has a high degree: the high threshold
        value (threshold = c3);
   Else if n>n3 and n≤ n4 then
        Node X has a very high degree: the high threshold
        value (threshold=c4
   Else if n>n4 and n≤ n5 then
        Node X has Ultra degree: the high threshold value
        (threshold=c5)
   End if
   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 while
   IF (c <threshold)        Submit the packet for
   rebroadcast
   Else Drop the packet from rebroadcast
   End
```

Fig. 1. Inspired Counter Based Broadcasting

In addition, Bani Yassein, et al [12, 15] proposed a counter-based broadcasting scheme with four counters. The proposed scheme maintains a better performance than the three counter-based in terms of different metrics. However, the proposed scheme would provide more efficient and dynamic result if it contains more counter values instead of four values also the proposed algorithm was implemented under AODV reactive routing protocol.

III. The Proposed Scheme

In the light of the observations above, our goal has been set to design an efficient and scalable broadcast algorithm based on a number of received duplicate packets. Since the node counter increases by one with every time of receiving the same broadcast message. Predefined threshold value is already given to each node in order to initiates rebroadcasting according to that threshold value. Thus, a new counter-based broadcast algorithm will be developed for MANETs. The algorithm has to present a major decrease of the number of redundant rebroadcast packets along with good results in terms of reachability.

In this section, we evaluate the performance of DSR-ICB or DSR-5C as broadcasting algorithm which can be applied to any type of broadcast operation. Such an operation is the dissemination of route requests (RREQ) in the route discovery process of on-demand routing protocols. For the purpose of discovering a route to a destination, it suffices that the RREQ reaches those nodes with a route to the desired destination. To study the impact of Inspired Counter Based Broadcasting on the route discovery process, we implemented it as the basis for deciding which nodes should broadcast RREQ messages in the route discovery process of DSR. We named the resulting protocol (DSR-ICB) or DSR-5C, and implemented it in Qualnet [11]. To compare DSR-5C against DSR with flooding (DSR-F), we use traffic and mobility models similar to those previously reported for the performance of DSR [8]. To address reliability, we have used three versions of DSR. First, DSR with Inspired Counter Based Broadcasting (DSR- ICB) we implement (DSR- ICB) or (DSR- 5C) as described in Fig. 1. Second, DSR with adjusted counter based (DSR-4C) [12, 15] and the last one DSR with flooding (DSR- F) [8].

IV. Simulation Result and Analysis

The Qualnet simulator has been used in this study which is a popular discrete-event simulator, originally designed for wired networks and has been subsequently extended to support simulations in mobile wireless (and MANET) settings [11].

Experiments are repeated for 20 trials with different random-number seeds, traffic endpoints. This means that all protocols are compared having identical node mobility and traffic demands. Each data point represents the average of the 20 trials. Since our algorithm is based on a counter based approach DSR with 5 counters (DSR-5C), it does not fit in every case. Notice that here is a small chance that the route requests cannot reach the destination in our counter based algorithm. In such cases, we have to generate the route request again if the previous route request failed to reach the destination. The DSR protocol, on the other hand, uses flooding in route discovery phase. Therefore, all route requests will reach their destinations if the network is not partitioned. Based on this analysis, our algorithm should perform better than DSR with flooding (DSR-F) and DSR with 4 counters (DSR-4C) in dense networks with heavy traffic [12, 15].

In our simulations, two nodes are selected as data sources. A CBR traffic generator has been attached to the sources. The mobility model chosen is random waypoint model. 50 nodes placed randomly on a 1000m x 1000m area and having bandwidth of 2Mbps.

To study the effects traffic loads, i.e. in this work varied traffic load have been used from light traffic through moderate to heavy traffic. To do so, the following rates of broadcast packets generated at the source node will be considered:

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

We measure the broadcast latency for three approaches. We record the start time of a broadcast as well as the time when the broadcast packet reaches the last node. The difference between these two values is used as the broadcast latency. Since rebroadcasts collide and content for channel with each other, and the counter based approach incurs the lowest number of rebroadcasts, it should have the lowest latency the number of total packets transmitted in the channel has a significant impact on the latency. If the number of packets is high, then the number of collisions is also high, and in turn more retransmissions are needed. As a result, fewer packets lead to lower delays. Fig. 2 shows the end-to-end delay for different levels of traffic load. As expected, our DSR-5C exhibit lower latency than the DSR-4C and DSR-F.

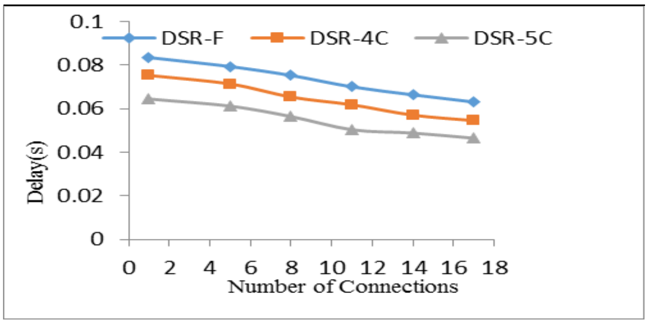

Fig. 2. End to End Delay vs. Number of connections

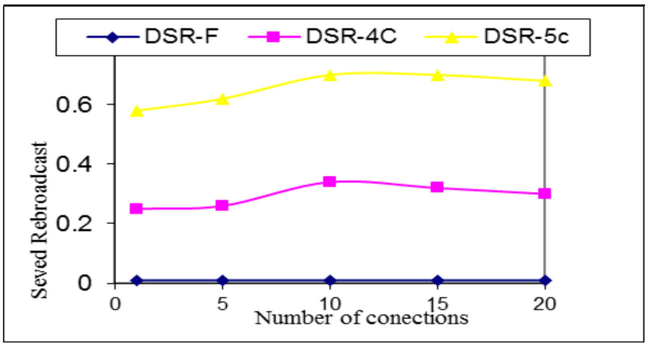

Fig. 3. Saved Rebroadcast vs. number of conections

Figure 3 shows that DSR-5C algorithm can significantly reduce the number of rebroadcasts for a network with 50 nodes and maximum speed 1 m/s. It also shows the number of route request rebroadcast increases when the traffic load increases. Fig. 4 shows that reachability increases when network traffic load increases, regardless of what kind of the algorithms is used. The DSR-5C algorithm has the best performance in reachability, reaching nearly 1. The performance DSR-4C shows that the reachability is above 95% in network traffic load equal 10.

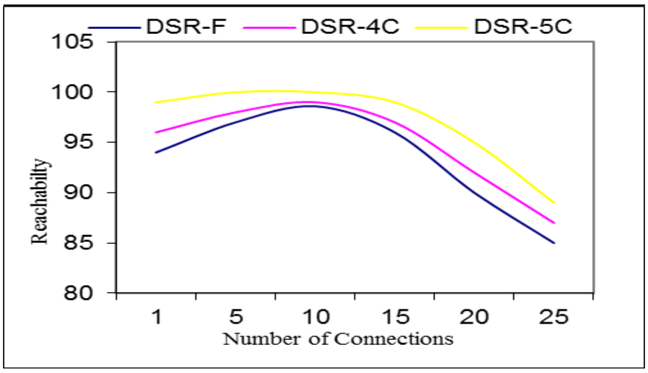

Fig. 4. Reachability vs number of connections

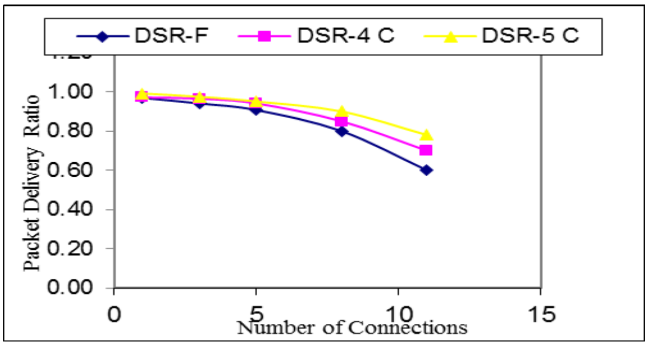

Fig. 5. Packet delivery ratio vs. number of connections

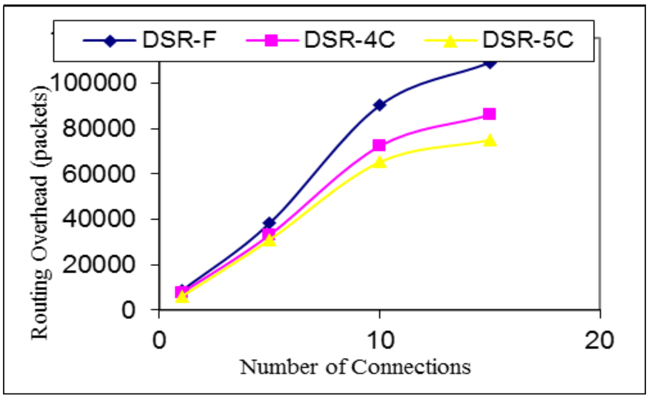

Fig. 6. routing overhead vs number of coneections

In Fig. 5, we compare the packet delivery ratio for different network traffic load. It shows packet delivery ratio decreases when number of connections increases. The drop of packet delivery ratio is caused by the fact that the movement of destination or intermediate nodes may incur route expiration and route request retransmission. The figure also shows that DSR-5C outperforms DSR-F and DSR-4C. As mentioned before, the packet delivery ratio improvement of DSR-5C is due to its reduction of rebroadcasting. Figure 6 shows routing overhead increases when traffic load increases. The more connections, the more route requests there will be, leading to more rebroadcasts and higher bandwidth consumption and higher routing overhead. It also shows that DSR-5C outperforms DSR-4C, DSR-F by 20%.

V. CONCLUSIONS

To improve the route discovery process of on demand routing protocols, a new counter based broadcast is implemented in DSR (the new variant is named (DSR-5C) as the mechanism for disseminating RREQ messages. Our simulation results show that DSR-5C improves, in all aspects, the performance of DSR in traffic load scenarios. We also show the performance of DSR with flooding based on both fixed and adjusted counter based under different working conditions. A performance analysis has revealed that the DSR-5C algorithm has superior latency characteristics over those of the well-known DSR with flooding algorithm. One of the key results is that the performance of the proposed algorithms scales up well with the increase of saved rebroadcasts.

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