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# An Effective Hierarchical routing protocol for VANET to disseminate safety messages

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**Abstract**: Vehicular Adhoc Networks (VANETs) are the special class of MANET which provides communication between vehicles. VANET provide a suitable environment for vehicles by giving the safety information thereby enhancing the traffic conditions. The most challenging issue in VANET is routing, which is achieved through broadcasting. This broadcasting should able to minimize the number of transmissions with guaranteed delivery. Due to the diverse network densities, the broadcast communication in VANET faces broadcast storm problem. This problem can be minimized by employing, (i) Minimum Connected Dominating Set (MCDS) technique at dense networks and (ii) Store-Carry-Forward (SCF) communication model at disconnected networks.

**Keywords**: Broadcast storm problem, Dominating Set (DS), Minimum Connected Dominating Set (MCDS), Store-Carry-Forward (SCF) model.

## I. INTRODUCTION

Nowadays Vehicular Adhoc Networks are grabbing much attention as they are believed to have a great capacity to enhance the traffic conditions [1,2], improve road safety and comfort to drivers. VANETs are believed to have a dynamic topology as the vehicles are highly mobile. Since, it cannot guarantee end-to-end connectivity.

*A. Broadcasting*

The fundamental networking operation in VANET is broadcasting which is performed for finding a route to a particular vehicle in the network. A simple broadcasting method is called flooding. Flooding allows each and every node to retransmit the message to all its 1-hop neighbours when receiving the first copy of the message [3]. This guarantees that messages reach all the nodes only if there is no collision and disconnection in the network.

*B. Broadcast storm problem*

When all the nodes flood the message in network at the same time, it causes more re-transmissions which results in redundant messages. This is referred to as broadcast storm problem [4].

## II. RELATED WORK

Several multihop applications were developed for Vehicular Adhoc Networks to propagate the useful traffic information within the geographical area. The impact of broadcast storms in VANET by message delay, packet loss rate, reachability and overhead were studied.

Xu Wu et al. [5] proposed Dynamic trAnsmission delaY based broadcast (DAYcast) protocol for data dissemination in a VANET. It reduces the effect of the broadcast storm and improves the transmission efficiency of the network, by allowing the effective neighbours of source vehicle to broadcast the received data packet. The selection is based on the position information on the one-hop neighbours of the source vehicle.

Manuel et al. [6] proposed a new adaptive protocol called Profile driven Adaptive Warning Dissemination Scheme (PAWDS). In this protocol, the warning message dissemination is improved. It uses an adaptive technique according to the scenario of the roadmap. PAWDS achieved an optimal performance depending on the features of the roadmap where the propagation takes place.

Kanitsorn Suriyapaiboonwattana et al. [7] proposed Adaptive Probability Alert algorithm (APAL), to overcome various problems in VANET that occur in case of accident alert information dissemination. The indiscriminate broadcast of alert message may cause the problem of broadcast storm. APAL does not need location information of the vehicle. The broadcast is set adaptively such that broadcast storm is minimized and lost alert-message problem is also controlled.

Ruina Liu et al. [8] claimed that an efficient multihop broadcasting algorithm, named Forward Acknowledgement based Broadcast (FAMB) is designed to address the broadcast storm in real time transmissions and also the reliability problems in multihop broadcasting. The FAMB adopts the following ways to control broadcast storm effectively: First, the forwarding node selection mechanism is defined to reduce the redundancy data and mitigate the broadcast storm. Second, RTF (Request To Forward) packet and ATF (Answer To Forward) packet with unit timeslot are designed to execute the algorithm.

## III. PROPOSED WORK

*C. Minimum Connected Dominating Set (MCDS) technique*

All the vehicles in VANETs uses wireless channel to communicate each other. It is assumed that two or more vehicles are called neighbours when the vehicles are in one hop communication range.

An undirected graph G = {V, E}, where V is the set of vehicles and E is the set of communication links between vehicles V represents this adhoc network. Vehicle ‘$V_i$’ represents a node in V and a communication link <$V_i$, $V_j$> between neighbor vehicles ‘$V_i$’ and ‘$V_j$’ represents an edge in E.

**Step 1: Dominating Set (DS) formation**

A Dominating set (DS) of G is a subset of V where each vehicle ‘$V_i$’ in V is available in DS or neighbor to a vehicle ‘$V_j$’ in DS. A connected dominating set of vehicles, CDS of G which is a connected sub-graph of G. The vehicles in CDS are able to communicate with each other without using the vehicles in V-CDS. The set CDS is called as Minimum Connected Dominating Set of Vehicles (MCDS), iff the set is minimal number of nodes in the CDS. Vehicle ‘$V_i$’ in CDS is MCDS vehicle and a link between two MCDS vehicles is called gateway link.

**Step 2: Minimum Connected Dominating Set (MCDS) formation**

The Minimum Dominating Set can be formed as follows: Choose a node from the set of nodes V which has maximum neighbor nodes and is not available in Dominating Set (DS). Include that node in the DS and remove that node and its neighbor from the set of nodes N. The chosen node is said to be dominator of CDS and the other neighbor nodes are said to be dominates. Repeat this step until the set N is empty.

In order to improve the routing performance and reduce the overhead packets in CDS, the size of CDS should be minimized to form MCDS. Every node exchanges a message with their nearby neighbor in order to put one-hop neighbor into its neighbor set $N_i$ at first to form CDS, and then each node exchanges their neighbour’s information with their neighbor in order to compute the reduced neighbor sets of every neighbor to form MCDS. For example, after exchanging the neighbor set $N_i$ information of node $i$ with all its neighbours, it forms the reduced neighbor set $RN_i$, which is computed as $RN_i = N_v – N_i$, where $N_v$ is the neighbor set of each and every node in the set V. Thus our reduced MCDS is formed which is explained below in the algorithm.

1) Algorithm for MCDS Formation

```
N=V
DS= { ∅ }
    While !EMPTY(N)
      Pick n which has maximum neighbor nodes
      DS= DS U {n}
      N= N-({n} U NEIGHBOUR(n))
    end while
CDS = DS
for all Ni of n in CDS
    Pick the neighbor set (Ni , Nv ) from N
    while ((Ni ∩ Nv) = ∅)
        Compute the Reduced neighbor set RNi
        RNi = Nv–Ni
      MCDS = CDS
    end while
end for
```

The route formation between source and destination in MCDS uses the Hello, Route Request and Route Reply packets for forming the route between source and destination. Hello messages have been used for to create MCDS and vehicles in the MCDS have been used for virtual local backbone of the network. The source vehicle broadcasts ROUTE_REQ packets to the neighbor vehicles. If vehicle $N_i$ is the target vehicle then send the route reply to the sender. If $N_i$ is already available in the route record of the route request packet or not a member of MCDS then discard the packet. Otherwise it appends the vehicle $N_i$ to the ROUTE_TABLE and sends ROUTE_REQ from vehicle $N_i$. This technique avoids the unnecessary overhead packets in the network. Hence, it eliminates the broadcast storm in the dense network. In conventional routing protocols, route request packets sent by the sender initiate the process of route formation. All neighbor nodes of the sender broadcast the route request to its neighbor until the packets reached the destination vehicle. Then the route reply packet sent to the source node by the destination node confirms the route formation process. But in this proposed routing protocol, only the nodes in the MCDS broadcast the packets until it reaches the destination node. It reduces the broadcast storm and reduces the bandwidth utilization and hence improves the packet delivery ratio of the network. The Fig. 1 depicted below shows the MCDS formation by finding the maximum one hop neighbours.

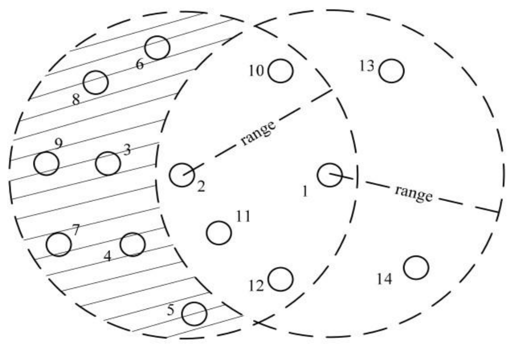


Fig. 1 MCDS formation

*D. Store-Carry-Forward (SCF) Communication Model*

Despite numerous efforts, most related works focus on either highway or urban scenarios, but not both. Highways are mostly addressed with a single directional dissemination. The MCDS suppression technique is not optimal for single-directional dissemination. To overcome this, we present an infrastructure-less protocol called Store-Carry-Forward (SCF) mechanism to support multi-directional dissemination.

In Store-Carry- forward mechanism, the node stores messages in the buffer and whenever it meets the destination node, it forwards the data packets. The adjacent neighbour nodes are determined by the position and moving direction in the network. Here the nodes make the decision for data dissemination based on current knowledge. The movement pattern of nodes should be concentrated. SCF network helps in connecting dynamically-changing movement pattern of the network

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and can able to make rough predictions about the future communicating nodes. The information is transmitted in a multi-hop fashion until the vehicle cannot find other vehicles at the target direction. Here the tail of one cluster stores all broadcasts received and rebroadcast them with indication that it is the tail. It is responsible for carrying these messages until the connectivity in the message direction is established. The tail then forwards its stored messages, until it encounters the front of destination cluster, in this way concluding the Store-Carry-Forward mechanism which is depicted in the Fig. 2. Vehicles in the non-tail state have two responsibilities: (i) store all messages sent by the tail, (ii) rebroadcast received messages at the same time by reducing retransmissions.

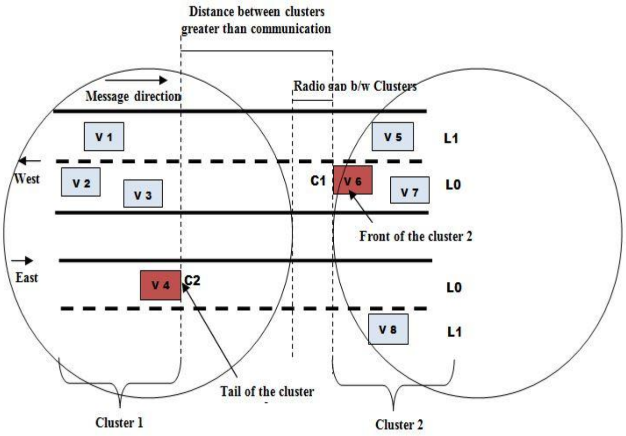


Fig. 2 Store-Carry-Forward (SCF) mechanism along two lane road

2) Algorithm for SCF formation

```
Message passing across 2-lane road between C1 and C2
Radio communication range of each node R = 250 m
    Examine message direction from S to D
    Consider S is at C1 and D is at C2
        For all Ni of N in C1
            Pick the neighbor Ni which is farthest along
        message direction
            Set farthest = 'tail'
        end for
        For all Ni of N in C2
            Pick the neighbor Ni which is farthest
        opposite to message direction
            Set farthest = 'front'
        end for
            If front does not come under R(tail)
                do operation (tail) = 'store-carry'
            else
                do operation(tail) = 'forward'
                While front ! = 'D'
                    do operation(front) = 'forward'
                end while
            Pass front(msg) to D
          End if
```

## IV. Experimental Setup

The proposed MCDS and SCF scheme takes the grid of 1500 X 500 containing the total number of nodes about 50 as shown in Table 1. Initially the one hop neighbors of every moving node is found by calculating the distance between each and every node $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. The one hop neighbor of a node can be determined only when the calculated distance value between the nodes is less than 250 m.

TABLE I SIMULATION PARAMETERS

| PARAMETER | VALUE |
|---|---|
| Simulation Area | 1500 X 500 |
| Number of Nodes | 50 |
| Transmission Range | 250 m |
| Message Size | 150 Bytes |
| Broadcast Interval | 0.05 s |
| Average Vehicle Speed | 50 Km/hr |
| Communication Environment | Vehicle to vehicle (V2V) only |

## V. Results

From the generated trace file the number of sent, received and dropped packets with time interval can be found. With the help of the awk script, the Packet delivery ratio and Average throughput can be calculated by giving the generated trace file as input. It can be inferred that it gives maximum throughput even though the environment is dense with 50 nodes which is depicted in the Table 2.

TABLE II CALCULATED METRICS

| PARAMETER | VALUE |
|---|---|
| Packet delivery ratio | 86.055721% |
| Start time | 1.732232 |
| Stop time | 300.0000 |
| Average throughput | 4.995122 kbps |

In order to assess the effectiveness of the proposed MCDS and SCF protocol, it is compared with the network performance of traditional broadcast approach and observed that MCDS and SCF give better results compared to those protocols. Performance has been evaluated in terms of average (*i*) throughput, and (*ii*) packet delivery ratio, by means of numerical simulations carried out with the ns-2.35 simulator. In this scenario, it is assumed that 50 vehicles are moving at constant speeds, and forming clusters only for a limited short-life time interval. It is also considered $D_{min}$ = 250 m that is a good trade-off with the transmission range (*i.e.*, $D_{min} = rtx/2$).

From the Table 2 it can be inferred that the proposed MCDS and SCF protocol shows robustness of success in spite of increase in number of vehicles and achieved the throughput of about 4.995122 kbps. For all other protocols, the overall throughput rate decreases rapidly with the increase in number of vehicles of network.

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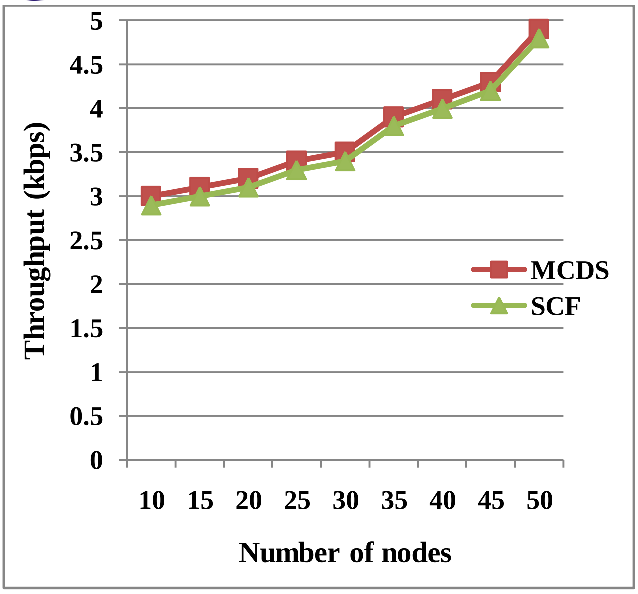


Fig. 3 Graph Showing Throughput of MCDS and SCF protocol against number of nodes

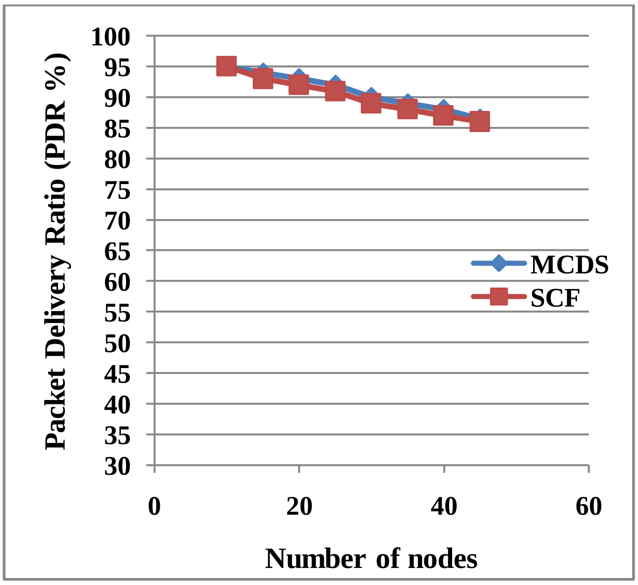


Fig. 4 Graph Showing PDR% of MCDS and SCF protocol against number of nodes

The above graphs in Fig. 3 and Fig. 4 show the comparison of Throughput (kbps) against number of nodes and Packet Delivery Ratio (PDR %) against number of nodes for the proposed MCDS and SCF. It clearly shows that it outperforms with respect to Throughput (kbps) and Packet Delivery Ratio (PDR %).

## VI. Conclusion

Thus the designed hierarchical dissemination protocol is suitable for both dense and sparse vehicular networks. The use of Minimum Connected Dominating Set (MCDS) technique has been motivated due to its increased throughput and packet delivery ratio. This MCDS based routing protocol reduces the retransmission of Route Request packets and it can prevent broadcast storm problem in VANETs. At the same time, the Store-Carry-Forward mechanism can able to work effectively in disconnected networks. The calculated values of throughput and packet delivery ratio show that even though the diverse vehicular environment is taken, it doesn't affect the overall throughput of the network.

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