A Novel Broadcasting Procedure for Vehicular Ad Hoc Networks to Minimize Retransmissions

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ABSTRACT
A reliable and efficient broadcast procedure is essential for the Vehicular Ad Hoc Networks (VANET) because a major portion of services need to broadcast the messages to the vehicles within a certain area of interest, The broadcasting should ensure a minimum number of transmissions and also should guarantee delivery. Several such broadcasting protocols have been implemented till date, but intermittent connectivity ehich is a property of VANET is not addressed. In the proposed work, the local information of the surrounding vehicles is used to construct a Connected Dominating Set (CDS). Vehicles in the CDS actively take part in message broadcast. As the total number of nodes which needs to forward the message is reduced, the number of retransmissions is reduced. Acknowledgements from neighbors include the message identifier which eliminates forwarding the messages to the same vehicles which have already received the message. Thus the overall network traffic is minimized. The proposed method does not depend on any parameter to broadcast the message. In simulation based approaches, the method provides high reliability and efficiency.

General Terms
Networks, Optimization

Keywords
Vehicular networks, broadcast, dominating set, data dissemination, ad hoc

1. INTRODUCTION

Vehicular ad hoc network is a special form of MANET which is a vehicle to vehicle & vehicle to roadside wireless communication network. It is a autonomous & self-organizing wireless communication network. The vehicles are equipped with wireless communication capabilities to facilitate message sharing. VANET is a technology that uses moving vehicles on roads as nodes in a network to create a mobile network. VANET assumes every participating vehicle as a mobile node, allowing vehicles that are approximately 100 to 300 meters to each other to connect and, thus creating a network with a wide range. As vehicles go out of the signal range and go out of the network, other vehicles can join in the network, so that a mobile Internet is created. The important systems that can integrate into this technology are the police and fire departments to broadcast safety messages.
Broadcasting is defined to be an one-to-all communication. i.e. a mobile node sends a message that should be received by all other nodes in the network (provided they are connected). This is also referred to as data dissemination. A broadcasting mechanism is the core of every mobile ad hoc routing protocol for route discovery or announcement. Most of the services ranging from safety applications to traffic applications and infotainment rely on broadcasting messages to the vehicles in an area of interest. Thus the design of efficient and reliable broadcast protocol is important for implementing different vehicular communication services. Figure1 shows a sample scenario of broadcasting in a typical VANET.
The most basic broadcasting protocol is the blind flooding, in which a source node transmits the message to all its neighbors, and then the node receiving it for the first time retransmit it. Assuming an ideal MAC layer, this protocol is reliable, that is, every node in the network will receive the message at least once. However, because of its simplicity, this protocol leads to a lot of duplicated packets and jams the whole network. Especially in a very dense network, as in car city scenarios, this setup leads to a tremendous overhead.

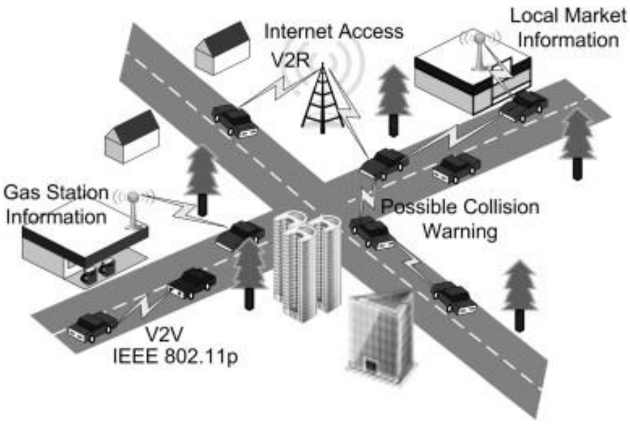

Figure 1 : Broadcasting in VANET

Unlike MANET, VANET has much more predictable nodes movement as vehicles are constrained to move by road directions only. It should not be concluded that the VANET scenario becomes easier as the node's speed is tremendous. In 10 seconds or less, the connection between vehicles can be broken in freeway speed. Broadcasting in VANET occurs when a vehicle wants to send a message to all other vehicles. The broadcast initiator starts by sending the message to its own neighbors. Due to the less transmission radius, that message cannot be heard by every intended recipient. Therefore, some vehicles must relay the message. The question that arises is who should relay so that bandwidth is minimally consumed. Yet, the broadcast has to be still reliable and delivered in fast fashion.
In this paper we focus on the problem of broadcasting with minimum retransmissions in VANETs without infrastructure support. Our primary goal is to achieve reliability at the cost of minimum transmissions.

2. LITERATURE SURVEY
Vehicle-to-vehicle communication can be used as a platform for opportunistic communication among people with shared interests. In [2] the authors discuss a virtual FleaNet over a VANET. Here the customers broadcast their query saying about

their needs and demands, which are used to find a vendor with matching resources. These queries are opportunistically disseminated exploiting the mobility of other customers in order to find the customer/vendor with matching needs/resources. FleaNet defines three message types: query, match, and transaction. A query message is used for representing the information about the goods that a person possesses or seeks. A match message is used to inform users that a node finds queries with a matching interest. A transaction message is used whenever a user wants to make a transaction request or respond to such a request.

In [3] two solutions are presented for vehicles travelling in the same direction. In the first solution, the car transmitting the message decides its next forwarder as the farthest neighbor in the network. In the next solution the next forwarder selection is performed at the receiver. This protocol does not guarantee delivery to all nodes as the farthest neighbor may lose its connectivity and may become unreachable.

A variant of this scheme is used to implement cooperative collision avoidance [4]. In cooperative collision avoidance scheme, when a car meets an emergency event, it starts sending wireless-collision warning messages (W-CWM) to all cars behind it. These messages are forwarded in a multihop manner to achieve full platoon coverage. On receiving a W-CWM, a driver in a farthest car can react by decelerating his car even before the tail light of the preceding car has lit. A high speed wireless communication network can help to design CCA systems that can improve highway safety by avoiding chain collisions. When a vehicle meets an emergency, it sends a W-CWM to all cars behind it in the platoon. Since the identities of receivers are not known in prior, usual routing will not work. W-CWM is broadcasted and then the recipients selectively forwards the message based on its direction-of-arrival. This ensures that W-CWM will be delivered to all vehicles in that platoon. Naïve broadcast proceeds as follows. On detecting an emergency event, a vehicle sends the W-CWM at periodic intervals. A vehicle can ignore the message if it comes from behind with respect to its direction of movement. If it comes from the front, then the vehicle starts decelerating and starts broadcasting W-CWM of its own.

The urban multihop broadcast protocol [5] is an 802.11-based solution targeted at reducing the broadcast storm while maximizing reliability. Multihop broadcast is essential to disseminate information to locations that are beyond the reach of individual nodes. Message broadcast is difficult in crowded urban areas with tall buildings because of the line-of-sight problem. Multihop broadcast protocol solves broadcast storm, reliability and hidden node problems. This is achieved by including black burst jamming signal, request-to-broadcast (RTB)/clear-to-broadcast (CTB) exchange. Reliability is ensured by acknowledgement messages. But the protocol's application is limited to dense urban scenarios.

When there is an intersection in the path of the packet dissemination, then directional broadcasts has to be done in all directions. Since there is a repeater at the intersection, it is the best candidate to initiate the directional broadcasts. This is because, among other nodes, repeaters have the best line-of-sight to the other road segments, especially when there are tall buildings around the intersection. When a node is selected to forward a packet and it is outside the transmission range of a repeater, the node continues with the usual directional broadcast protocol. On the other hand, if the node is inside the transmission range of a repeater, it sends the packet to the repeater using the point-to-point IEEE 802.11 protocol. A node sends RTS to the repeater and only the repeater replies with the CTS packet if the channel is empty. Upon receiving the CTS packet from the repeater, the node sends the DATA packet and the transmission ends when it receives an ACK packet from the repeater. After receiving this broadcast packet, the repeater initiates a directional broadcast in all road directions other than the direction where it received the packet from.

Three probabilistic and timer-based broadcast suppression techniques have been proposed in [6]. A node will broadcasts the packet with a fixed probability if it receives the packet for the first time, else it will discard the packet. Their objective is to minimize the broadcast storm problem. The mitigation strategy includes three broadcast schemes that allow each node to calculate its own reforwarding probability based on its local information.

The Distributed Vehicular Broadcast (DV-CAST) protocol [7] is the solution that explicitly addressed the various connectivity conditions of the vehicular scenarios. The algorithm depends on whether or not a sparsely connected vehicle moves in the same direction as the original message source. Routing solutions are proposed for each regime and to disseminate the broadcast message efficiently. A per-hop routing based approach which uses only local connectivity information (1-hop neighbor topology) is used to make a routing decision. The motivation for using local connectivity in the broadcast protocol design is to ensure the maximum reachability of the broadcast message.

Blind flooding has been replaced by a method where each cluster head, CH and gateway node in a clustered wireless network forwards the message exactly once [8]. CHs and gateway nodes together form a connected dominating set. The distributed clustering algorithm is initiated at all nodes whose id is lowest among all their neighbors (locally lowest id nodes). Nodes with more neighbors are more likely to become cluster head. In case of ties, lower id nodes gain advantage of becoming a CH. Non-CH nodes that can hear two or more CHs will declare themselves as gateway nodes.

With the knowledge of the existing broadcast protocols we propose an adaptive broadcast protocol which is suitable for a wide range of mobility conditions. While broadcasting is easier through the process of flooding, performance overhead lies in the number of retransmissions within the network to achieve reliability. The proposed work will overcome the redundant transmissions to a greater extent than many existing approaches.

3. BROADCAST PROTOCOL

The main issue of the broadcast protocol in VANETS is the existence of different vehicular scenarios. It should ensure high coverage of the network at the expense of fewer transmissions, regardless of the size of the network. The proposed protocol will satisfy these requirements.

The protocol is localized and depends on the available neighborhood information. Connecting Dominating Set (CDS) and Neighbor Elimination Scheme (NES) are employed to minimize redundant transmissions. It assumes ideal communication links to connect the network and in calculation of CDS and the related operations. When a node receives a broadcast message, it sends an acknowledgement to the node which forwarded it. This aids in eliminating the neighbors which have already received the message from receiving redundant messages.

In VANETS there is no fixed or pre-defined infrastructure. Nodes in wireless communication networks communicate through a shared medium and this may reduce network performance due to increased radio interference. Backbone nodes will remove unnecessary transmission links by shutting down some of the redundant nodes. Some nodes are selected as dominator nodes and all the nodes in the network can directly or indirectly communicate through these dominator nodes. The dominator nodes form the CDS and they perform the forwarding of messages in broadcasting process.

In Figure 2 [14] the black nodes are the dominating nodes.

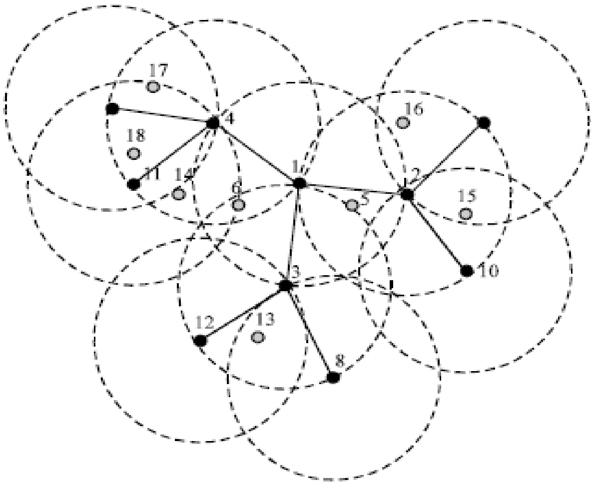

Figure 2 : A Schematic CDS construction

Given an undirected graph G = (V,E), a subset V' ⊆ V is a CDS of G if for each node u ∈ V, u is either in V' or there exists a node v ∈ V' such that uv ∈ E and the sub graph induced by V'. (i.e.) G(V') is connected. With the help of CDS, routing is easier and can adapt quickly to network topology changes.

Assume that each node x is identified by a unique key key(x). Then, a node is said to be an intermediate node if it has two unconnected neighbors [7]. A node u is covered by neighboring node v if each neighbor of u is also a neighbor of v, and key(u) < key(v). A node u is covered by two connected neighboring nodes v and w if each neighbor of u is also a neighbor of either v or w (or both), key(u) < key(v), and key(u) < key(w). An intermediate node not covered by any neighbor becomes an intergateway node. An intergateway node which is not covered by any pair of connected neighboring nodes becomes a gateway node. A set of gateway nodes form a CDS. Our protocol is not tied to any CDS heuristic and any of them can be employed.

3.1 Constructing a CDS

The problem of designing efficient broadcast protocols for adhoc networks has been deeply investigated for several years. The most common technique to reduce redundant transmissions in a broadcasting task is the use of connected dominating sets. CDS may be used to limit the broadcast storm problem, by limiting broadcasting nodes to those gateway nodes. A dominating set is the set that any node in the network either belongs to the set or is the direct neighbor of some node in the set.

Let G(V,E) be the graph induced by the network topology, so that V is the set of nodes in the network and E represents the connectivity between them. Then, a subset $V_D \subseteq V$ is said to be dominating if each node in V either belongs to V_D or has at least one neighbor which belongs to V_D. V_D is a CDS if it is connected. In CDS-based broadcasting, only those nodes belonging to the CDS will retransmit the broadcast message, the message will eventually reach the whole network. Therefore, fewer number of nodes in the CDS, less redundant the broadcast protocol will be.

The procedure for finding CDS is as follows. Assume that each node x is identified by a unique key key(x). Then, a node is said to be an intermediate node if it has two unconnected neighbors. A node u is covered by neighboring node v if a neighbor of u is also a neighbor of v, and key(u) < key(v). A node u is covered by two connected neighboring nodes v and w if each neighbor of u is also a neighbor of either v or w (or both), key(u) < key(v), and key(u) < key(w). An intermediate node not covered by any neighbor becomes an intergateway node. A set of intergateway nodes form a CDS.

Algorithm ConstructCDS

```
{
        Input     : Neighbor list of each node
        Output    : List of CDS nodes
        for {i=0 to total_num_of_nodes}
        {
                // set variables intermediate(i) and gate(i)
                as false
                // set covered true
                foreach element of neighbor(i)
                {
                    set i1 = neighbor(i)
                    foreach element of neighbor(i)
                    {
                        set i2 = neighbor(i)
                        if {dist(i1,i2) >
transmissionRange}
                        {
                                set inter(i) = true
                                if {i > i2 && i > i1}
                                {
                                                set
                        covered false
                                }
                        }
                    }
                }
        }
}
```

This method requires one-hop knowledge of neighbors with their position or two-hop neighbor topology information. Such information is obtained through periodic beacon messages exchange. Each node makes decision about its CDS membership without communication between nodes beyond the normal message exchanges that nodes used to discover each other and establish neighborhood information.

3.2 Broadcasting

The communication overhead of broadcasting can be significantly reduced by eliminating the redundant transmissions. This can be achieved by relaying the message through the CDS nodes which are the internal nodes of the network. This method can be explained by the flowchart in Figure 3.

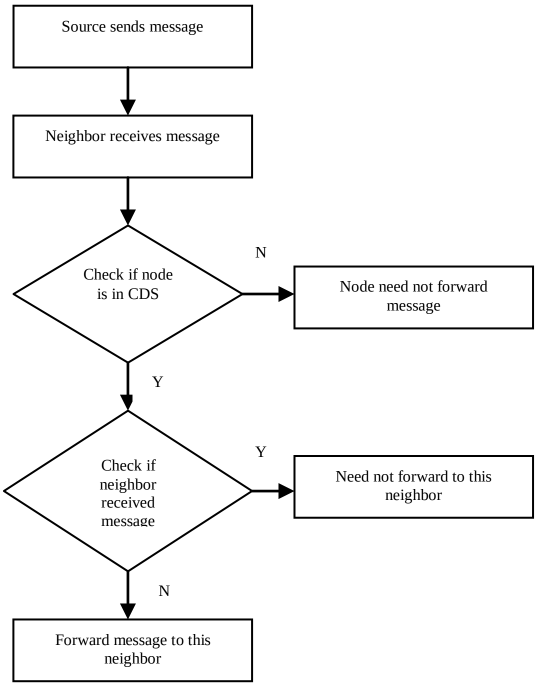

Figure 3: Broadcasting flow

When a node receives the message, it checks whether it is within the CDS backbone. If so, it will forward the message to its neighbors. If not it will keep the message by itself and sends back an acknowledgement. This process reduces the number of retransmissions significantly. The intelligent flooding may happen as follows: Source node transmits the packet. Nodes not in the CDS need not retransmit the packet. Upon receiving the the message, a node in the CDS eliminates from its forwarding list those neighbors that have already received a copy of the same message and forwards the message to the remaining nodes of its forwarding list.

Algorithm BroadcastCDS
{
Input :List of CDS nodes, message to be broadcasted in network
Output : receivedList
L1 : for each message received by $node_i$
{
receivedList = receivedList U $node_i$
broadcast an acknowledgement
if ($node_i \in$ CDS)
{
broadcast message to neighborList($node_i$)
goto L1
}
}
}

3.3 Eliminating Redundancy

The broadcasting scheme can be improved by the neighbour elimination scheme. A node will rebroadcast the message only if it has a neighbour that might need the message. Some of the neighbours are eliminated for rebroadcasting if it has already received the message.

In neighbour elimination scheme, a node does not need to rebroadcast a message if all of its neighbours are covered by the previous transmissions. After each reception of a message, a node eliminates from its rebroadcast list, the neighbours that have already received the same message. If the list becomes empty, then the node need not rebroadcast. Suppose node i broadcasts a message to node j. Set N_i and N_j denote the neighbours of node i and j, respectively. When node j receives a broadcast packet from a node i for the first time, it determines its coverage set Cj as the difference between Set N_i and N_j. This keeps track of pending hosts in j's neighbourhood, which have not received a direct broadcast from node i as they are outside node i's broadcast range. Node j does not rebroadcast the packet if Cj is an empty set. An empty set implies that all neighbours of node j are also neighbours of node i.

A receivedList is maintained which includes the nodes that has received the message. When a node receives a message, it sends an acknowledgement to the network. The corresponding node's id is added to the receivedList and removed from the forwarding list of the other CDS nodes in which it is present. Thus redundant transmissions will not reach a node and the number of retransmissions are reduced. Finally the source sees the receivedList to check whether all the nodes has received the broadcast. If not, it will send the message to those neighbours to ensure reliability.

Algorithm EliminateRedundancy
{
Input : receivedList
Output : Updated forwardingLists
for each $node_i$ in receivedList
{
for each $node_j$ in the network
{
if ($node_i \in$ neighborList($node_j$))
{
remove $node_i$ from forwardingList($node_j$)
}
}
}
}

Blind flooding in ad hoc networks may be used as a fall back mechanism that provides more reliable broadcasting in situations of increased mobility, channel noise, or packet traffic where optimized broadcasting mechanisms may fail. This reliability is due to the inherently high degree of redundancy present in blind flooding whereby all nodes retransmit received broadcast packets at least once. However blind flooding results in the broadcast storm problem.

Optimized broadcast mechanisms have to reduce the level of redundancy during a broadcast, thereby reducing the broadcast storm problem. However, there exists a significant problem in broadcast environments where a message may be lost due to packet corruption, packet collision, or hidden node problems. Therefore, it is possible that nodes may not receive a broadcast transmission. These nodes that do not receive the broadcast transmission has to receive a transmission.

The proposed approach makes the source node to take care of this. The source checks the receiveList to see whether all the nodes in the region has received the broadcast. If not, it will directly send the message to those nodes. Thus reliability is achieved.

4. DISCUSSION

Our simulation work has been done in Network Simulator ns-2, version 2.34 with the simulation parameters as given in Table 1. The performance of the proposed approach is compared with that of the traditional flooding method in broadcasting. It is found that the number of retransmissions has reduced to a greater extent. Experimental analysis has been done in the given topology with different number of nodes. Each time, varying CDS is obtained. The number of retransmissions is found to be inversely proportional to the number of CDS nodes.

Table 1: Simulation Parameters

Simulation Parameter	**Value**
Simulator	NS 2.34
Network Area	2000 x 1000
Node Transmission Distance	200
Simulation Time	150 seconds

The proposed protocol proves to be an appropriate solution for VANETs than many existing protocols. The protocol is scalable as it needs only location information to broadcast the messages from desired nodes to other nodes. This does not increase the message overhead in the network. Acknowledgements serve as the best solution to guarantee delivery to all vehicles.

CDS heuristic reduces the number of message transmissions. The time out for CDS nodes are lesser to give them higher priority to retransmit. This is appropriate for vehicular scenarios in which the vehicles at the converging streets or junctions are chosen as the CDS nodes which have higher oppurtunities to communicate with a large number of vehicles. This is achieved by the inherent use of the CDS selection procedure, without ever considering about the notion of intersection in roads. Other VANET specific protocols have to explicitly deal with intersections by starting new broadcasts in those directions.

The performance of the proposed approach is compared with that of the traditional flooding method in broadcasting. It is found that the number of retransmissions has reduced to a greater extent. Table 5.2 shows the simulation results.

Table 2: Number of transmissions in Flooding Vs ABSM

Number of nodes	**Flooding**	**ABSM approach**
20	98	43
26	123	55
30	155	68
36	172	73

5. CONCLUSION AND FUTURE WORK

We have implemented a localized broadcast protocol for vehicular ad hoc networks. It uses location information and acknowledgements of messages so far received to enhance the protocol's reliability and efficiency. We have studied the scalability as the number of data sources increases. The proposed protocol turned out to be robust and reliable and significantly reduces the number of transmissions required to complete a single broadcast. We plan to continue the work in different vehicular contexts and looking forward to reduce the protocol overhead when there are simultaneous broadcasting tasks.

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