Real Time Traffic Handling Using Ring Broadcasting in VANET

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Abstract: A vehicular ad hoc network (VANET) uses vehicles as mobile nodes in a Mobile ad hoc Network (MANET) to create a mobile network. Vehicles on the road usually move in one direction or in one pattern which we can use for creating network on the road. Every vehicle which is moving on the road can act as router and used to create network and with the help of this network packets can be disseminated in the VANET. Vehicular ad hoc network (VANET) provides the communication between vehicle to vehicle for providing information to travelers with new features and applications that have never previously been possible. Already ample amount of work is done for this. Routing is the important issue for which various protocols have been designed for VANETs, one of them is RBVT routing protocol. Routes are sequences of road intersections in RBVT, and for sending packets between the intersections geographical forwarding is used.

This paper proposes real time traffic handling using ring broadcasting. Distributed protocols are used for unicasting packets in the network for finding the topology graph. The topology graphs show the traffic on the roads and ensure connectivity between intersections and this graph is distributed to all the available nodes in the network. Already available cellular links are used for sending the road connectivity information. Connectivity graph is computed by centralized server and distributes it to the nodes, broadcasting is required for distributing information here ring broadcasting shall be used to improve performance and to avoid duplicity and redundancy.

Keywords: *VANETs,* Dissemination*, MANETs, Centralized Information Packet, Wi-Fi Link, Cellular Communication.*

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INTRODUCTION

A vehicular network in general is a network of vehicles that can communicate with each other; the network could be formed by use of infrastructure such as cellular or road side fixed equipment or on-the-fly in an ad hoc manner. The vehicular network that is formed in ad hoc manner without need of infrastructure is called a *Vehicular Ad-hoc NETwork* (VANET).

One of the core issues of vehicular networks is designing efficient and scalable routing protocols. Such protocols are needed for most of the applications to come to reality. The development of new routing protocols is important because not only will they enable the addition of new dimensions to the vehicle through various applications in areas such as vehicular safety, but they will also transform it from being a mere transportation means to a smart vehicle. The requirements of routing protocol in VANET are significantly different than what they are in wired network or *Mobile Ad hoc NETwork* (MANET). Some of the major differences in VANET are (i) Mobility: due to which the topology is highly dynamic, (ii) Road layout: a node moves on the road, which constraint the packet to follow the road path, and (iii) Obstacles: due to which the communication on close-by parallel streets is restricted.

In past, the research has been focused on finding variants to MANET protocols and changing some of their parameters (to overcome issue of highly dynamic topologies) or developing reactive/geographical VANET protocols. Some of these protocols [11][12] do use the right approach of using road intersections as part of their routes but fail to use the real time traffic information or propose an expensive solution of deploying infrastructure such as deploying sensors to get the real-time traffic information.

II. RELATED WORK

The research group in the UbiNetS lab at NJIT proposed *Road-Based using Vehicular Traffic* (RBVT) routing. As the name suggests, RBVT leverages real-time vehicular traffic information to create road-based routes. The created routes are successions of the road intersections that have, with high probability, network connectivity between them. A packet between consecutive intersections is forwarded using Geographical routing; this approach decouples routes from individual node movements [19]. There are two main advantages in RBVT: (a) adaptability to topological changes by incorporating real-time vehicular traffic information and (b) stability in route by use of road-based routes and geographical forwarding.

Route Construction: Routing is a process of moving packets through the network. It consists of two separate, but related, tasks: (a) Defining paths for the transmission of packets through the network and (b) Forwarding packets based upon the defined paths. The tasks are achieved with the help of routing table. RBVT being proactive protocols the routes tables are updated for every known change of topology. Usually the protocols [8, 9, 10] that have been derived from MANET use node centric approach, these protocols do not work well due to the dynamic nature of the network. The other protocols [11, 13, 14, 15] use the road- based approach, these protocols use the right approach but most of them [11, 15] do not factor in the current road traffic and rather try to use the shortest distance to reach from source to destination, which currently may not have any traffic. The protocols fail to consider traffic flow; some of the protocols [14, 12, 16, 17] try to work around this problem by using historic data. Due to the events such as road constructions or traffic redirections which are not rare, the historical data does not remain an accurate indicator of the current road traffic flow.

The RBVT protocols use road intersection as their building block. When a source wants to transfer data to the destination, instead of tying particular nodes to the route towards the destination it uses the road intersections. As long as the road segments remain connected it does not matter if the connectivity between the individual nodes on a road segment exists. The fault in binding a particular node to a route is due to the node movement, it ma y not remain in the sight of the route.

Forwarding: A node periodically broadcasts hello messages; the receiving node updates its neighbor table using the information provided in hello message. If a hello message is not received from a particular neighbor within a time interval the entry is purged; non -receipt of hello messages is a strong indication that the other node is travelled out of communication range. When the source node wants to transmit data to destination node, it queries the routing table for the available routes to the destination; if there are multiple routes from the source to destination, the route with minimum number of intersections is used. This desired route is stored in the packet for reference of the intermediate node. The protocol uses loose source routing to forward data packets in order to improve the routing performance. The intermediate nodes are free to change the path in the packet if they have latest connectivity information. The node that stores or updates the route information in the packet also writes the timestamp of the connectivity graph that was used for determining this route. The intermediate node compares its connectivity graph timestamp to decide if a better routing decision can be made. Due to the high volatility there could be route breaks, in such cases the intermediate node tries forwarding the data packet using geographical forwarding method until it reaches a node that has fresher information and there exists a route from that node to the destination; this newly found route is updated in the packet and forwarded further towards the next intersection. In between intersections the packet is forwarded using geographical forwarding; this is advantageous as the node always selects the farthest possible neighbor node to forward the packet.

In this class of routing there are particularly two advantages: (a) it is adaptive to network topology changes by using real - time vehicular traffic information and (b) the stability of route through road-based routes and use of geographical forwarding.

A. RBVT-P

RBVT-P is a proactive routing protocol for VANET; it periodically discovers and disseminates the real -time road connectivity graph. The source node uses the connected shortest available path to the destination. The path consists of intersections that are found connected in the real -time view. RBVT-P uses a location service, to find the destination position. Due to the dynamic nature of the network, RBVT –P does not bind the forwarding of packets to a particular node like AODV (which are node centric).

Topology Discovery: The topology is discovered by use of *Connectivity Packet* (CP). The CP is a packet that traverses the connected road segments and stores the visited intersections in it. This information is later used to create the connectivity graph which is then disseminated in the network to other nodes. The CPs are generated periodically by a number of randomly selected nodes in the network. The CP packet traverses the road intersection by use of algorithm similar to DFS graph traversal, as the packet moves from one intersection to other intersection the road segment is marked as connected otherwise as un - connected. The CPs are periodically generated by a CP generator node, they are unicasted to discover the network topology.

Topology Dissemination and Route Computation: The node that finally receives the CP on the generator segment extracts the information in the CP to generate a *Connectivity Graph Update* (CGU) packet and disseminates the CGU to other nodes in the connected network. Upon receiving the latest CGU, each node updates its routing table and re - computes the shortest paths to all other connected intersections. One of the fields of each entry in CGU is timestamp, with the use of this field the node determines whether the information it already has or the information the CGU contains is the latest one. The timestamp of each entry is retained in the routing table to identify and remove the stale entries at later point of time.

When the source has to transmit information to the destination it determines and uses the shortest path through the connected intersections. The path is made of sequence of intersections and is stored in the header of the data packet. The packet is forwarded geographically between the consecutive intersections, defined in the path. The protocol uses loose source routing so the intermediate node is free to update the path if it has more recent information about the topology.

Route Maintenance: The RBVT-P generates CP frequently (which in turn generates CGU) that keeps the nodes updated with the topological changes. The CPs are generated from different section of the network so that the information of particular section is gathered by the nodes in that section. The node in an isolated section cannot know the connectivity information about other section till the disconnection between these isolated networks is bridged.

The frequency of generating CP would depend on the network size and density of nodes in the section of the network. Higher the density, lower number of packets are required as the probability of finding the replacement node increases. In a CP generation interval, multiple CP are generated to avoid the problem of loosing connectivity information in a CP round when CP packet is lost. The CP passing protocol is not a reliable protocol but a best effort delivery so there are chances of them getting lost.

B. Broadcasting in ad hoc networks

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). A broadcasting mechanism is the core of every mobile ad hoc routing protocol for route discovery or announcement.

The most basic broadcasting protocol is known as the blind flooding, in which a source node transmits the message to all its neighbors, and then each node that receives it for the first time reemits it [20]. Assuming an ideal MAC layer, this protocol is reliable, that is, every node in the network will receive at least once the message. 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.

A more intelligent protocol, named Neighbor Elimination Scheme (NES) has been proposed. Its principle is as follows. Each node that receives a message for the first time does not retransmit it immediately, but waits for a given duration, which can be computed or randomly generated. While waiting, the node monitors its neighborhood and after each received copy of the broadcast message, it eliminates from its rebroadcast list neighbors that are assumed to have correctly received it. If the list becomes empty before the node decides to relay the message, the reemission is canceled. This protocol allows some bandwidth savings by canceling redundant emissions, while still insuring an entire coverage of the network. But every node needs to know its neighbors. In turn, this can be bandwidth consuming in a fast changing network as in vehicular ad hoc networks.

Another category of protocols is based on the computation of a connected dominating set S. A set is a dominating one if each node in the graph is either in S or a neighbor of a node in S. The broadcasting step, in its simplest variant, can be described as follows. When a node receives a broadcast message for the first time, it drops the message if it is not in the considered connected dominating set or retransmits it otherwise. Nodes ignore subsequent receptions of the same message. When the neighbor elimination scheme is applied, some transmissions may be avoided. A node that is in the dominating set, but observes that all its neighbors have already received the same message, can also dr op the packet without retransmitting it. But calculating such a dominating set requires a lot of bandwidth. Even worse, once such a dominating set is calculated, it is already out dated because of the fast changing scenario.

A further broadcast improvement is the so-called geoflood . The geoflood algorithm assumes that each node can discern its own location, but it does not require each node to know the location of its neighbors. This is an important distinction because learning the location of other nodes is usually done by means of a “hello” protocol, which adds additional protocol messages [21]. Today, nodes can easily obtain their location through already popular GPS devices. It makes sense to assume that a car, which is equipped with a WLAN system, also has an onboard GPS system for example for a navigation system. In geoflood each node waits a short period of time before forwarding on the first reception of the message as in NES. A node abstains from forwarding a message when it receives the same message from all geographic directions. A location field carrying the position of the sender extends a routing packet. Each node defines a Cartesian plane with its own location as the origin. A node will abstain from forwarding only when it has received the message from all four quadrants (NE, NW, SE and SW). Thus the algorithm works as follows: If the local node has forwarded the received message earlier, the message is dropped. If this is the first reception of the message, the quadrant from which the message arrive d is recorded, and a packet holding time *t* is chosen. The message is temporarily put on hold until either the message is received from all four quadrants or *t* time has passed. If the message arrives from all four quadrants before time *t*, then the message is dropped, otherwise it is forwarded and the (source, sequence) pair is stored in the forwarding cache to filter future duplicates. An important part of the algorithm is the selection of packet holding time. Nodes furthest away from the local sender should select the smallest packet holding times. These are the nodes located near the perimeter of the sender’s transmission range. Holding times increase as the distance to the sender decreases, with those nodes closest to the sender waiting the longest.

For cars, the geoflood algorithm has one major disadvantage. A car on a straight route will nearly never be able to receive a packet from all for quadrants. One now can tend to propose to reduce the four quadrants only to two. But this will lead to serious problems at crossings. geoflood is no option for vehicular ad hoc networks. So we have decided to develop our own broadcasting mechanism for avoiding unnecessary route request, the Ring Broadcasting.

III. PROPOSED WORK

Importance of this proposed solution come from the use of real-time traffic information and the way route between the source and destination is created. Unlike the MANET protocols, the proposed framework use road intersections as a part of route. Road intersections are stationary; having them in route is more advantageous than having a moving vehicle. The difference with respect to other VANET protocol is that the proposed solution use real-time traffic information rather than the historic data. The use of road intersection as the guiding point helps when a moving vehicle goes out of range from the guided point. This vehicle (that moved out of range) can be replaced with other vehicle near the road intersection to forward the packet towards the destination. The need for such mechanism arises due to the highly dynamic changes in the topology. The proposed framework being proactive is expected to be better in terms of end to end delay i.e. lowering the delay of end to end communication.

A. Design

Centralized framework with ring broadcasting for real time traffic in Vehicular Ad hoc NETworks uses the concept of proactive protocol. It uses a concept called as Centralized Information Packet (CIP) that is similar to CP used in RBVT-P. The car node on the road considers itself the most forward if it does not receive any packet for a timeout interval; similarly it considers itself most backward if it does not find any node to which it can send the CIP. The nodes backward/forward direction is irrespective of the driving direction; each road in the map is assigned a direction that is stored along with digital map in the node. The communication between the node and the server takes place using the Cellular technology whereas the communication between the nodes is through Wi -Fi wireless technology.

Topology Discovery: The most forward node on the road sends the CIP to the node behind it. The intermediate node continues forwarding this packet to the node behind it, eventually reaching the most backward node (no other node behind it on that road which this backward node can communicate). This most backward positioned node on the road sends the gathered connectivity information through its GPRS interface to the server. The connectivity information entry is of the form < FirstIntersectionID, LastIntersectionID, ExpirationTime>; where FirstIntersectionID indicates the intersection id from where the connectivity begins, LastIntersectionID indicates the end intersection till the connectivity on the road segments exists and the ExpirationTime indicates the time till the road segments are valid. The expiration time is calculated by addition of Maximum connectivity valid period (protocol configurable value) and current time. The connectivity information is gathered for the segments through which a CIP traveled. The CIP may also implicitly indicate the nonconnectivity of two segments the one before the FirstIntersectionID and the one after LastIntersectionID to the block of connected segments. The server receives one CIP from each set of connected nodes; there can be multiple CIPs for the same road depending on the connectivity pattern on the road. For e.g. in Figure 1 on road segment S1 of road R3, the five nodes create an isolated network from the nodes on segment S2 on the same road, in these cases there are two different CIPs that are sent to the server from these two sections on the same road. In the figure R1, R2 and R3 indicate roads and S1, S2 and S3 designate the segments on the roads. The pair

<Road><Segment> uniquely identifies the segments. The car nodes on the roads are named N1, N2, N3 and N11.

The car N1 being the most forward node on road R1 starts a CIP, every node that has the responsibility to send this packet tries to send it the most farthest possible node so that the discovery of information is faster and this also makes the protocol more efficient.

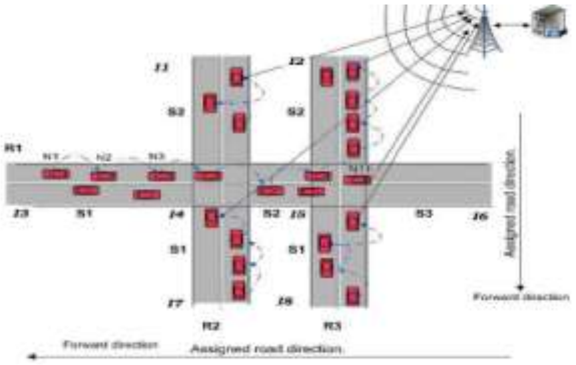

Figure: 1 Most backward cars on the each road send CIP to server. After computing the real-time graph it is sent to the node which sent this CIP.

In the example N1 skips node N2 and sends the packet directly to N3 as N3 is in the wireless range of N1. The packet is similarly forwarded to the most backward node (in this case N11), which then sends the packet to the server for re-computing the real-time graph. I1 to I8 indicate the intersections or end points of the roads .

Topology Dissemination and Route Computation: On receipt of each CIP the server updates the connectivity graph. In comparison with RBVT -P, this same task is done by the node that finally received the CP from the segment where it was initiated (this indicates that an iteration of connected graph is complete). Once the server rebuilds the connectivity graph, it transmits this graph back to the node that sent the CIP that triggered the graph computation. The node then disseminates this information by broadcasting it to the neighbors. This continues till the most forward node receives the information. Similar to RBVT -P each node then runs Dijkstra’s algorithm on the newly received connectivity graph to find the shortest path to all the connected segments in the map. Further on, when a source node wants to transmit data, it stores the connected available shortest path in the packet header. These routes, represented as sequences of intersections, are stored in the data packet headers and used by intermediate nodes to geographically forward packets between intersections.

To give an example of how the above process contribute to the view of a node. In figure 1, say node N11 is the last node to send the CIP out of the five CIP s sent to the server. The time difference of the CIP sent should not be more than α, where α is the period between the round of CIP generation. On receipt of CIP from N11, the server recomposes the graph and sends it to node N11. The node views the received graph as shown in figure 2, the dotted lines indicate no connectivity between the intersections (or on that segment) and the bold lines imply the connected component of the graph from the intersection I5 at which node N11 is present. The road segment S2 of road R2 is not reachable as there is no node in the connected graph that could communicate with the cluster of nodes that are present towards intersection I1. Similarly as there is no node towards the intersection I6, that intersection remains unconnected from intersection I5.

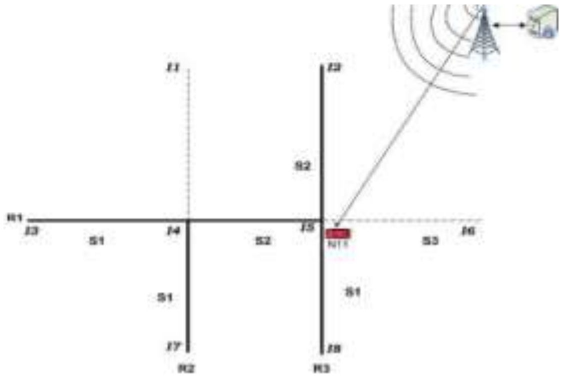

Figure: 2 View of most backward node on road R1 after receiving the updated connectivity graph from the server.

From figure 1 it is seen on road R3, the segments S1 (I5 to I8) and segment S2 (I2 to I5) generated two different CIP s, which mean that nodes on those segments are not able to communicate due to the distance between them, but as seen in figure 5.2 the graph is created as showing them connected; the server generated the graph with global view. The nodes at the intersection I5 on road R1 can bridge the gap to forward the traffic between the disconnected segments S1 and S2 on road R3.

Route Maintenance: In framework, the forward node on the road frequently generates the CIP, which eventually gathers the connectivity information of the road segments that are connected and sends it to the server. The server sends the computed graph to the node that recently reported the connectivity (CIP). This node disseminates the information to its neighbor and those neighbors send it to their neighbors and so on.

B. Ring Broadcasting in VANET

Ring Broadcasting is specialized for broadcasting route requests. The main target of it is not only to minimize broadcasting messages but also to get more stable routes. Standard AODV just uses blind flooding. For route establishment it takes the route over which it has received a request for the first time. This is a route with very few hops close to the least required number of hops. Like this always the nodes, which are very far away from each other, will be taken. This is not a good idea for dense networks with fast moving nodes. Like this route breaks very often because the distance between the nodes is very close to the maximal transmission range. On the other hand it makes no sense to take intermediate nodes that are very close together. On one hand this would minimize route breakage but on the other hand this would lead to an unacceptable increase of delay and network load.

Ring broadcasting handles them both together in a fairly clever way. Since only nodes that rebroadcast a route request, can become an intermediate node, we limit rebroadcasting to specific nodes. Like this we automatically reduce the amount of unnecessary broadcasting messages and decide which node may become an intermediate node of a route and which not. For deciding which node rebroadcasts a request and which not, we first have to define three different groups of receiving nodes.

- Inner Nodes (IN):
  They are close to the sending node.
- Outer Nodes (ON):
  They are far away from the sending node.
- Ring Nodes (RN):
  They are at preferred distance from the sending node.

Using the received power, the classification of a node in one of the three groups can very easily be done. A node has just to calculate how much the received power is above the receiving threshold, from now on called receiving power difference (rxDiff). Like this we need to define two new thresholds, one for delimiting the inner nodes form the ring nodes and another for delimiting the ring nodes from the outer nodes. We correspondingly call them Inner Border Threshold (IBT) and Outer Border Thresh old (OBT). Not to forget that the maximal transmission range is a natural third border (maxTxRange).

With this broadcasting technique we can improve the performance of the proposed framework.

IV. SIMULATION

The evaluation of proposed framework can be done using Network Simulator NS-2 [7] simulation. The movement of the vehicles is generated using open -source microscopic, space-continuous and time discrete vehicular traffic generator package called as SUMO [18]. SUMO uses a collision-free car-following model. The map is inputted into SUMO, the information such as road speed limits, traffic lights and number of lanes is also inputted. The output file from SUMO is converted into the required node movement format of NS -

2 simulator.

For the wireless configuration , at the physical layer, the shadowing propagation model is used to characterize physical propagation. The communication range of 400m with 80% probability of success for transmissions is set. The obstacle model simulates buildings in a city environment; the contour of each street can either be a building wall (of various materials) or an empty area. Thus for each street border, the signal attenuation value is set to a randomly selected between 0dB and 16dB.

V. METRICS

The evaluation performance of these routing is done using different Constant Bit Rate (CBR) data rates, different network densities and different numbers of concurrent flows. Following are the various metrics to evaluate the performance:

Average delay: This metric defines the average delay occurred for the transmitted data packets that are successfully delivered. The average delay characterizes the latency introduced by each routing approach. For a proactive protocol this is the primary metric, unlike reactive protocols proactive protocols maintain routes between source and destination which leads to reduced delays.

Average delivery ratio: This metric defines the number of data packets successfully delivered at destinations per number of data packets sent by sources (duplicate packets generated by loss of acknowledgments at the MAC layer are excluded). The average delivery ratio gives the measure of the routing protocol to transfer end-to-end data successfully. **Average number of hops:** This metric defines the average number of nodes that are part of successful packet delivery from source to the destination. Historically, the average number of hops was a measure of path quality. This metric is used to study if there is a correlation between the number of hops and average delivery ratio and average delay, respectively.

Overhead: This metric is defined as the number of extra packets per number of unique data packets received at destinations. The number of extra packets consists of routing packets (i.e. routing overhead) and duplicate data packets. Therefore, the overhead measures the total overhead per successfully delivered packet.

VI. CONCLUSION

This paper presented the framework for real time traffic environments that take advantage of the road topology to improve the performance of routing in VANET. Simulation results may show that the proposed framework outperforms existing approaches in terms of average delay, average delivery ratio and low overhead. Because the RBVT protocols forward data along the streets, not across the streets, and take into account the real-time traffic on the roads, they perform well in realistic vehicular environments in which buildings and other road characteristics such as dead end streets, traffic lights are present. As cellular link

would more commonly be available, we used a server with cellular communication to show how the performance can increase if the control plane (i.e., the routing traffic) is routed across the cellular link whereas data is transmitted over the Wi–Fi link in ad hoc manner. Because of ring broadcasting the traffic can be reduced and performance can get enhanced.

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