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A Novel Approach to Reliable Message Broadcasting in Vehicular Ad hoc Networks by Prioritizing both Messages and Density Based Regions

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Abstract
Vehicular Ad hoc Networks (VANETs) are an outgrowth of traditional Mobile Ad hoc Networks (MANETs). VANET is mainly used to model communication in a Vehicular environment where the vehicles are considered as VANET nodes with wireless links. It enables the communications among vehicles and between vehicles and Road Side Units (RSU). In Peer-to-Peer communication, a vehicle can send message to any other vehicle in the network. In doing so, if the destination vehicle is farthest from the source vehicle, then propagation delay is more for the delivery of messages. For a better delivery ratio and to reduce broadcast storms, a message has to be relayed through intermediate nodes known as representative nodes (RN)s to the destination. The main requirement of VANET is location information. Using Greedy Forward algorithm, messages to farthest nodes are transmitted by computing RNs. Though we communicate with the farthest node through representative nodes, due to the special characteristics of VANETs such as high mobility, unstable links or dynamic nature of vehicles, representative nodes positions are to be computed dynamically. If the information about the high density region and low density region are gathered then the problems that arise with sparse VANETs also can be minimized. Otherwise the prior approach sends information to low density region continuously than high density regions. This problem can be minimized if we apply DBSCAN algorithm to form clusters (regions) using location information, then high density regions can be given highest priority for message transmission. As VANETs main characteristic is urgent message transmission, the messages are to be prioritized and then transmitted over the network. In this paper, Greedy forward approach and DBSCAN algorithms are pipelined to increase the performance of broadcasting messages over the VANET. In addition to this, in this paper, we also prioritize the messages for urgent message transmission over the VANET. This provides hybrid solution to the lossless instant messaging mechanism as this works on real time environment.
Keywords: VANET, Representative Node (RN), Road Side Unit (RSU), Global Positioning System (GPS),Greedy Perimeter Stateless Routing (GPSR) , DBSCAN (Density Based Spatial Clustering of Applications with Noise).

1. Introduction
Vehicular Ad-hoc Network (VANET) is a subset of Mobile Ad-hoc Networks (MANETs), which consists of a set of vehicles, equipped with a communication device called On Board Unit (OBU), and a set of stationary units along the road, referred to as Road Side Units (RSUs)[1]. On Board Unit devices are used to communicate with the devices in other vehicles and also with road side units (RSUs).The road side units are connected with backbone network. The moving vehicles have access to internet through the backbone network [2].

Based on Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R) communications, VANETs can support a wide variety of applications in road safety and traffic optimization as [3].First, safety and warning messages could be used to alert drivers as to dangerous and unpredicted situations, and thus restrain the number of accidents or reduce their severity. In addition, such systems can improve road utilization by managing traffic flows. Traffic updates can be delivered in real time to allow time saving and lower fuel consumption. Finally, such systems can be used for exchanging multimedia content and advertising purpose. Therefore, research of VANETs has been receiving increasing interest in the last couple of years.

The following shows various types of communication in VANETs.

1.1 VANET Architectures:
The VANET architectures are shown as in Figure 1.
1.1.1**.** V2I (Vehicle to Infrastructure*)*: This is vehicle to infrastructure communication (Global System for Mobile

communication, UMTS, WiMax, Wi-Fi/Mesh, etc.) and is used to collect information from nodes.
1.1.2. V2V (Vehicle to Vehicle) Communication: This is vehicle to vehicle architecture where both the collection and distribution of messages are done within the network for faster delivery of messages.
1.1.3. Hybrid Communication: This involves communications among vehicles and between vehicles and road side units (RSU)s.

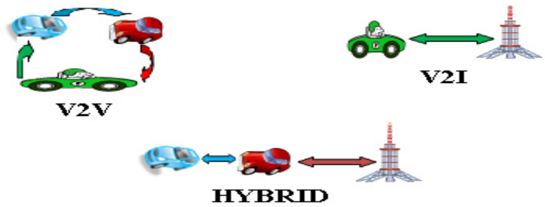

Figure 1. Vehicular Communication Architectures

In all the above three types of architectures, the key concern is to transmit messages to the intended destination with minimum propagation delay and maximum reliability. Due to dynamic nature of VANET nodes, sometimes there is no guarantee about successful message transmission. To obtain maximum packet delivery ratio, in this paper both greedy forward approach and DBSCAN algorithm are used to classify the high/low dense regions there by prioritizing both regions and messages for efficient broadcasting over the VANET through RNs. This paper is organized as follows: Section II describes about Related Work to find nodes positions by using GPS, Section III describes our proposed work which includes (i) Broadcasting by finding RNs using location information by applying Greedy Forward approach. (ii)Finding High density and low density regions using location information by applying DBSCAN algorithm. (iii)Broadcasting taking into consideration priorities of the messages and density based regions. Section IV contains the results and discussion which includes the comparison of broadcasting messages with priority and without priority. Finally, Section V discusses about the improving the performance of data dissemination by giving priority to messages as well as high density regions.

2. RELATED WORK

In VANETs Vehicles can move in predictable manner. Geographic locations of the vehicles are tracked through GPS, the Global Positioning System [4, 5], is composed of 24 satellites which can orbit around the earth. Each satellite circles the earth at a height of 20.200 km and makes two complete rotations every day. The orbits have been designed in such a way, in which any region of the earth can be observed at least by four satellites. A GPS receiver is an equipment able to receive the information constantly being sent by the satellites and using it. The GPS receiver uses the Time of Arrival Technique (ToA) to estimate its distance to the four known satellites, and trilateration technique [6, 7] to compute its position. Once these procedures have been executed, the receiver is able to know its latitude and longitude.

In VANETs routing is important for reliable messaging between V2V and V2I. VANET deals with different types of routing protocols like Geographical / Position Based Routing for effective communication in Vehicular Environment. One such protocol is Greedy Perimeter Stateless Routing (GPSR)[8] discussed by Brad Karp et al. can be used to transmit message to the farthest nodes by finding RN positions through GPS. In this paper, in addition to that sparse VANETs are identified by forming clusters (regions) using DBSCAN [9] algorithm discussed by Henrik Bäcklund, Anders Hedblom, Niklas Neijman et al. for reliable communication over the network. A common assumption in connectivity models for VANETs is that a vehicular network is partitioned into a number of clusters [10].Vehicles within a cluster can communicate either directly or through multiple hops among each other. In this paper the messages in each cluster are broadcasted through representative nodes (RN)s.

3. METHODOLOGY

To transmit messages to farthest regions without fail, the dynamic path is chosen using GPSR algorithm. As the chief characteristic of VANETs is location information, this is to be updated dynamically. To do this, regions are prioritized based on the density to improve the effectiveness of communications. As emergency messaging requires high priority messages to be transmitted first, messages are to be prioritized. Broadcasting occurs by considering the priority of the message and then by considering the region to enhance the effectiveness of the transmission.

Various stages involved in transmission:-

1. Initially, track the Geographic locations of the vehicles and identify RNs based on the nodes that are farthest from the source and nearest to destination using GPSR algorithm. Then message transmission takes place through Representative Nodes.
2. Apply DBSCAN algorithm to VANET for identifying high density/low density networks.
3. Prioritize the messages as well the high/low density clusters.
4. Transmit messages by considering priority of the message/priority of the high density clusters calculated using GPSR/DBSCAN algorithm

(i) Finding RNs using location information by applying Greedy forward approach:

Vehicle location is tracked by GPS by receiving signals from satellites that transmit continuous coded information, which makes it possible to identify locations on earth by measuring distances from the satellites. Geographic locations of VANET nodes are tracked using GPS tracker and are used for finding the RNs for effective delivery of messages. The distance between two nodes is computed by converting latitude, longitude positions into meters. Each node is provided with a GPS receiver. The location information of node is recorded by the GPS receiver. The distance is measured between the satellite and GPS receiver that is placed in the node.
This involves two steps:

Step1: Finding distance of each vehicle through its location information:

Generally the distance between two nodes on the road is computed by considering two parameters such as latitude and longitude of those nodes. The shortest distance between any two points on the surface of a road measured along a path on the surface of the road. Let (**lts, lns, ltf, lnf**) be the geographical latitude and longitude of two points (a base "standpoint" and the destination "fore point"), respectively, and (**dLt, dLn**) their differences and the '**c**' (spherical) angular difference/distance, or central angle, which can be constituted from the spherical law of cosines. Then the distance (**d**) is computed by multiplying radius(**r**) with central angle(**c**).Finally, the distance in meters is obtained by multiplying previously computed distance with 1000.
The following function shows how to track the distance between source and destination nodes in meters through its location information.

```
////////////////////////////////////////////////////////////////////////////////////////////////////////
function compute( lts , lns , ltf , lnf ){
    var R=6378.137 ;  //Radius of earth in KM
    var dLt=( lt2 - lt1) * Math . PI / 180;
        var dLn=( ln2 - ln1) * Math .PI / 180;
        var  b = Math.sin(dLt/2) * Math.sin(dLt/2) +
        Math.cos(lt1*Math . PI / 180) * Math.cos(lt2*Math . PI / 180)*
         Math.sin(dLn/2) * Math.sin(dLn /2);
        var c=2 * Math.btan2(Math.sqrt(b) , Math.sqrt(1-b));
        var d=R*c;
        return d*1000;  //distance in meters it returns
}
//////////////////////////////////////////////////////////////////////////////////////////////////////////
```

Once the location information of a node is tracked, then apply GPSR protocol for computing RNs and to transmit messages through them to the destination.

Step2: Broadcasting messages by applying Greedy forward approach:

Greedy Perimeter Stateless Routing (GPSR): A novel routing protocol for wireless datagram networks that uses the *positions* of routers and a packet's destination to make packet forwarding decisions. GPSR makes *Greedy forwarding* decisions using only information about a router's immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recuperates by routing around the *perimeter* of the region. By keeping state only about the local topology, GPSR scales better in per-router state than shortest path and ad-hoc routing protocols as the number of network destinations increases. Under mobility's frequent topology changes, GPSR can use local topology information to find correct new routes quickly.

The Figure 2 shows communication in VANETs by applying greedy forward approach.

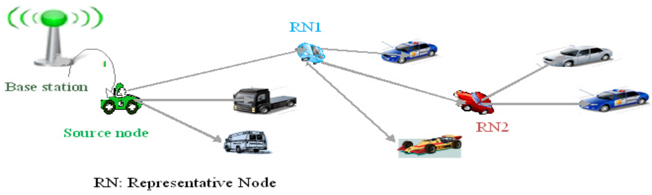

Figure 2. Communication in VANET based on GPSR protocol

Figure 2 clearly describes how the representative nodes (RN) play key role to send message to the intended destination. Initially the message is send by the base station to the source node (first node) then source node broadcasts message within its communication range. The node which is farthest from the source node within its communication range is marked as representative node for further transmission. This scenario is repeated for marking other representative nodes for further transmission of message until the destination is reached.

The GPSR algorithm for computing Representative nodes is a given below.

Algorithm GREEDYFORWARD(p)

n_{best} = self.a
d_{best} = DISTANCE(self.l,p.l)
for each(a,l) in N
do d = DISTANCE(l,p.l)
if a == p.a or d<d_{best}
then n_{best}=a
d_{best}=d
if a == p.a
then break
if n_{best} == self.a
then return greedy forwarding failure
else forward p to n_{best}
return greedy forward success

(ii) DBSCAN algorithm to VANET for identifying high/low density networks:

Though we broadcast messages through Representative nodes it requires prioritizing networks as high/low dense networks for effective traffic control. This can be achieved by organizing nodes in the form of clusters using location information. In VANETs If the information about the high density region and low density region are gathered then the problems that arise with sparse VANETs can be minimized, then high density regions can be given highest priority for message transmission.

DBSCAN (Density Based Spatial Clustering of Applications with Noise):

Clustering is the process of grouping vehicles with similarity in VANETs. By clustering vehicles into groups with similar patterns, it would be possible to provide more reliable and effective communication [11]. DBSCAN algorithm is used to identify clusters in VANETs by looking at the local density of nodes. By using the density distribution of nodes in the network, DBSCAN can categorize these nodes into separate clusters.

The following two parameters are needed to form clusters using DBSCAN algorithm.

Eps: Maximum radius of the neighborhood.

MinPts: Minimum number of points in an Eps-neighborhood of that point.

For a node to belong to a cluster it needs to have at least one other node that lies closer to it than the distance Eps. The Eps-neighborhood of a node A is node B, if

$$N_{Eps}(A) = \{B \in D \mid dist(A, B) < Eps\}$$

In DBSCAN, the nodes can be classified as either core node or boundary node.

Core node: The node which is within the cluster**.**

Boundary node: The node which is on the boundary of the cluster

DBSCAN Algorithm

- Arbitrarily select a node N
- Find all nodes which are density reachable from N w. r. t EPS and MinPts.
- If N is a core node then a cluster is formed.
- If N is a boundary node, no nodes are density reachable from N and DBSCAN visits the next node.
- This process is repeated until all of the nodes have been processed.

Cluster formation in VANETs using DBSCAN algorithm is as shown in Figure 3.

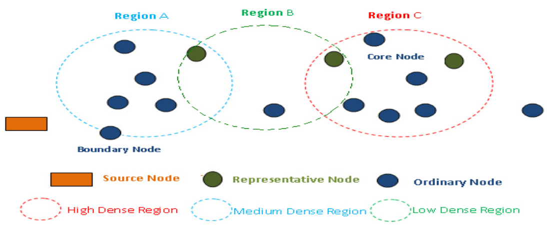

Figure 3. Clusters formation in VANETs using DBSCAN

In the above figure there are three regions named as region A, region B, region C. From the figure it is clear that Region C is high density region among the three regions so that it takes first priority for message broadcasting.

(iii) Broadcasting by taking into consideration priorities of the messages and density based regions

At this step, both density regions and messages are to be prioritized before broadcasting takes place. It involves two steps. First regions are prioritized based on density as high/medium/low. Next, messages are to be prioritized according to their importance and then broadcasted over the network. For effective traffic monitoring the priority must be given to high density regions. So that broadcasting messages from source node reaches to high density regions prior to low density regions. The following table shows the way the messages are to be broadcasted based on the priorities of both regions and messages

Table 1. **Priorities of messages broadcasting over VANET**

Region	No of Nodes	Message	Priority
A	5	Be alert	2
B	2	Thief Entering Network	3
C	6	Accidental message	1

Message broadcasting based on priorities of both messages and regions

The following Figure 4 shows complete proposed architecture. Here there are three regions named as Region A, Region B, and Region C. First priority is given to Region C for messages broadcasting as it is high dense region and then Region A, Region B and so on. It also shows the messages order as 3, 2,1 which means that message with priority 1 is transmitted first then message with priority 2 and so on to the region C, then region A and so on.

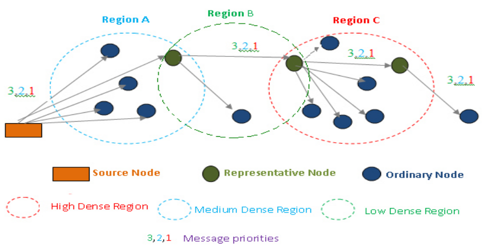

Figure 4. Messages broadcasting based on priorities of both messages and regions

From the Fig.ure 4., it is clear that, we can get maximum packet delivery ratio with minimum propagation delay. We can also say that messages can be transmitted to the destination without any link failure due to Representative Nodes (RNs) involved in a network. This provides a reliable solution to the real world environment.

4. RESULTS AND DISCUSSION

A. Node density versus Time without priority

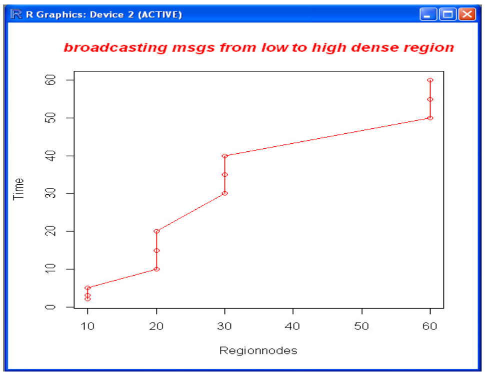

Figure 5. R graph for Region nodes versus Time without priority

The above Figure 5 shows how messages are to be broadcasted from low dense region to high dense region. The problem with this approach is that the representative nodes (RNs) send messages to the sparse regions first and then dense regions, due to this the propagation delay is more for the delivery of messages to the dense regions. Sometimes, there is no guarantee about the successful message transmission due to link failure. This is not a suitable approach in real world environment if there is an urgent message to be broadcasted over the network.

B. Node density versus Time with priority

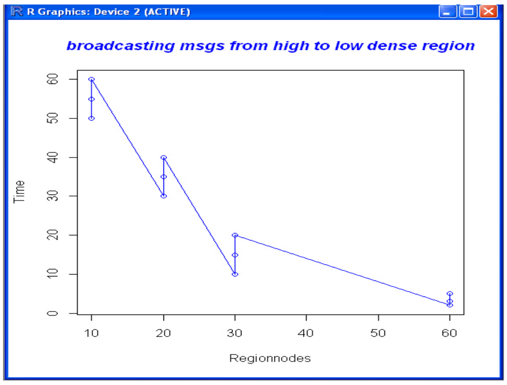

Figure 6. R graph for Region nodes versus Time without priority

The above Figure 6 shows how messages are broadcasted from high dense region to low dense region. This approach gives guarantee about successful transmission of messages to the destination with high reliability ratio. At every region there are three points which indicates the number of messages along with their priority. It also shows critical messages are to be broadcasted to high dense regions prior to sparse regions. This approach leads to a better solution for effective traffic control and in monitoring real time environment.

5. CONCLUSIONS

The analysis discussed in this paper combines the performance of both GPSR (Greedy Perimeter Stateless Routing) protocol and DBSCAN (Density Based Spatial Clustering of Applications with Noise) algorithm for broadcasting messages over the VANET. Here both the regions (Clusters) and messages are prioritized before broadcasting. The proposed approach minimizes the continuous broadcasting of messages to the sparse regions thereby reducing propagation delay for the delivery of messages to the intended destination.

It is to say that the performance of our proposed technique is satisfactory and it can be useful in real time applications especially to monitor the traffic and guarantee delivery of critical messages to the intended destinations. This work can be extended by considering other network parameters to enhance the network performance.

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