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Overview of Algorithm for Clustering in VANETs

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Abstract:
VANETs are formed for safe mobility of vehicles by providing easy communication between them. For ensuring better communication clusters of vehicles are formed. A cluster helps to ensure that all the vehicles are reached and enables vehicle to vehicle communication. Messages to be propagated between vehicles are of two types 1. Man generated and 2. Sensor generated. In general VANET cluster is formed by moving vehicles in the same direction and one vehicle will act as cluster head and all of them communicate using WAVE technology, and they will also communicate to the roadside unit. As the vehicles move in the same direction cluster also moves and nearby road side units also changes. With the advent of new communication technology Cellular IoT, it has become possible that mobile networks can be used for communicating IoT messages. In order to implement the same technology into VANETs we reconstruct the clustering technique to be central to the mobile tower or any range in a geographical area, once the vehicle enters into that area it will become member of that cluster and start communicating with other vehicles. The optimization algorithm binds the cluster to a geographical area, may be based on the tower accessibility and GPS location. Clusters formed based on tower accessibility will enable take advantage of cellular IoT, so that vehicles can directly send and receive messages through cellular tower with other vehicles. Formation of cluster will enable multicast, there by restricting sending messages to vehicles who are not intended. And can also send broad cast whenever message applies to more than known vehicles.

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1. INTRODUCTION

In general VANETs divides the routing of messages into two parts first Vehicle to vehicle and Vehicle to RSU (Road Side Units) where WAVE is used as transmission technology, second RSU to RSU where Long range transmissions are used. With the use of Cellular IoT long range communications can be easily achieved along with the advantages such as power saving, reduced network delay etc., Vehicles are free to transmit the safety messages on to Cellular Network along with the location information so that the vehicles on the same direction can be alerted. Use of Cellular IoT enables vehicles to communicate with the other vehicles directly without forming a cluster[1]. But the safety messages communication requires that some safety messages require the recipients are decided prior to communication, Ex: A vehicle applying a sudden brake can transmit the message to all vehicles in the cluster formed already with a small delay[2]. If the cluster is not formed then the message has to be broadcasted to the network along with GPS information which will result into the network traffic, and also and the vehicles coming on the way has to compare their own position with the received position to check whether they are the affected or not to take the necessary action. This will introduce more delay in taking action. Solution is to divide the messages based on their severity where delay is allowed and delay is not allowed [3].

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Messages to be propagated

Message	Reasonable Delay	Scope
Emergency Signals (Turns/Brakes)	<1s	Within cluster and previous
Road Blocks	<5s	Within cluster and Broadcast
Slippery Roads	<1s	Within Cluster and Broadcast
Approaching Ambulance	<1s	Within Cluster and next
Wrong way Vehicle	<1s	Within Cluster and previous
Traffic Jams	General Info not time constraint	Within cluster and Broadcast.

2. CLUSTERING IN VANETs RELATED WORK

Clustering of vehicles which uses WAVE technology can be clustered based on the vahicles movement direction and closeness based on the number of hops required to communicate with cluster head is explained in [4]. Formation of cluster is based on cluster head and cluster member but the node parameters in a VANET include the position of vehicle in [5]. Different techniques of clustering in the VANETs are well studied in [6].

3. LOCATION BASED CLUSTERING IN VANETs

VANETs may use different routing techniques. Ad-Hoc, Cluster, Broadcast, Geocast, Position based. Etc. in the wake of GPS becoming popular and cheap, the position based routing is getting evolved technology. We need an architecture that will combine the waning message along with the GPS information [7].

Requirements of the architecture:

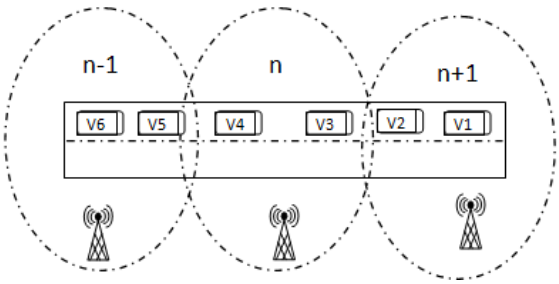
- Receive the messages from Vehicles.
- Identify the vehicles that are in the same region and moving in the direction to form a cluster.
- Allow the vehicles within the cluster to communicate each other.
- Check the authenticity of the messages received.
- Monitor the messages propagated for unwanted message communication and block those vehicles.

Clustering of vehicles:

In order to simplify the communication and speedy delivery of messages, vehicles are to be allowed to communicate with each other. To achieve this first the system has to decide which vehicles are to form cluster, and in this case the vehicles close together and moving in a particular direction are to be clustered.

Under each tower at least 2 or more clusters exist. Vehicles moving in one direction clustered and opposite directions vehicles will form another cluster. Question of clusters at junctions is established one for each direction.

Vehicles are clustered based on tower coverage or geographical units of 8-10KMs in Highways or 1KMs in Urban area however since urban traffic is considered to be number of times higher than Highway traffic, hence cluster size may be more or less same for highway traffic as well as urban traffic.



Inter-cluster messages: even clustering is done to minimize the process of sending and receiving messages, some messages are meant for vehicles of other cluster. Consider a vehicle V3 moving from cluster n to cluster n+1. Then an alert such as sudden

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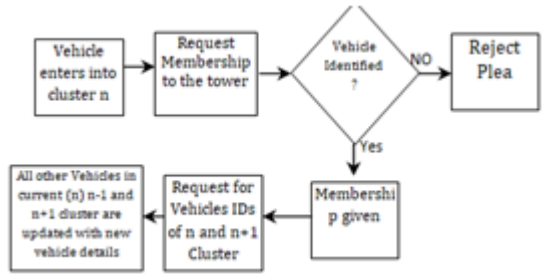
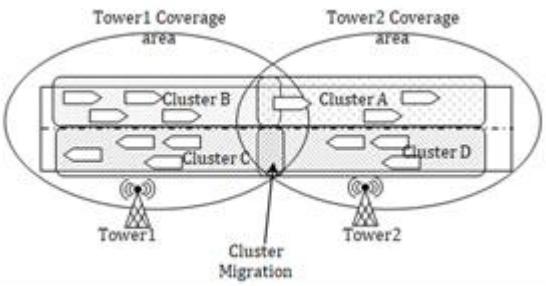
braking, wrong way vehicles coming opposite, slippery roads etc may be communicated to vehicle V4 that is within the cluster, even then the information may be helpful for vehicles v5 and v6. Suppose the vehicle v6 is an ambulance and it may trying to inform vehicles v5, v4, v3 next to it for give way, however vehicles v2 and v1 are far for alerting from v6 [8].

One thing we can understand from this is some alerts are to be processed to vehicles in the previous or next cluster also. So even though a vehicle is in cluster n, it may have to know vehicles in cluster n-1 and vehicles n+1. There may be some possibility that a vehicle in n might have passed through cluster n-1, and knows the vehicles in that cluster, but as this vehicle moves from n-1 to n, other vehicles might also moved from that cluster. And there is no way for a vehicle to directly access vehicles info in the other cluster. Tower in current cluster should get information from its adjacent towers and keep a track of that list and update that list periodically [9].





Formation of VANETs uses Hybrid architecture which is a mix of position based as well as clustering. A vehicle while registering itself in the VANET will send its identity number, GPS location, direction, length of the vehicle and average speed to the server. Capabilities of NB-IoT systems to transmit to a longer distance of more than 10 KM in open space and ability to penetrate into basements of buildings, enables VANETS to establish clusters in Highway traffics as well as urban traffic [10]. The server upon receiving the registration info tags the vehicle to a cluster which is geographically fixed. Here cluster is not formed by group of vehicles but by geographical area.

The vehicle is given with details of other vehicles in the cluster, with whom it can communicate. And at the same time other vehicles are updated with the details of this newly registered member. Normal life time of a vehicle in the cluster may be around 5-6 minutes. If the vehicle is in urban area vehicle will be moving with less speed and the tower coverage is also less. Similarly in a highway traffic vehicle speed will be more and the coverage of the tower is also more [13].

A cluster area may be fixed with GPS locations but due to the variations in signal strength the vehicle may choose to remain in the current cluster until it gets good connectivity with next Tower than the current one, as most of the alert messages sent are useful for only vehicles coming from behind. Also a vehicle moved just out of the one cluster to another keeps data of vehicles until it crosses that cluster too. Very few of the messages would be for the interest of the vehicles mobbing forward and in the next cluster also, such as ambulance alert. Ambulance alert is processed for the vehicles moving next to this for giving way to the emergency vehicle.

Alert Processing: Alert messages sent from vehicles may be of different types and the recipients may vary. Road patterns or vehicular movement paths are a very complex issue where mobility model is not as simple as a geometrical shape [11]. It consists of junctions where roads joining at a point may exceed 4-5 also. Road will not be as simple as one side is reserved for one directional vehicles. And opposite vehicles take other end. In some cases opposite moving vehicles are also allowed. Width of the road is also not uniform it may wide or narrow in some

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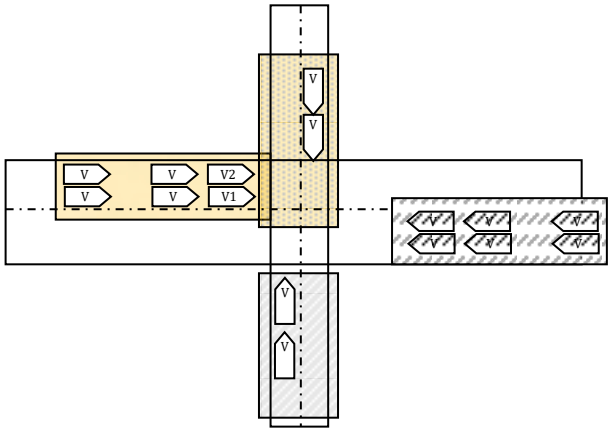
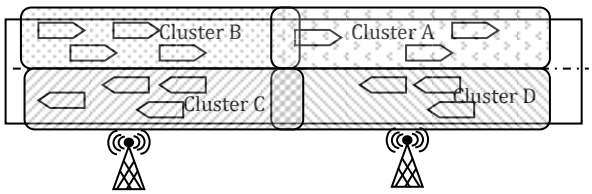
places. Any how we first analyze basic alerts for disciplined traffic patterns [12].

1. **Vehicle Turning Alerts:** these alerts are raised by the vehicle taking turn itself. Affected vehicles are vehicles in the cluster coming behind, and the vehicles in the cluster where the vehicle is taking turns.



Ex: if the vehicle V2 is taking turn towards left, then the vehicles in the cluster and the vehicles in the left side shaded with dots in the fig are to be alerted. And if the vehicle needs to take a right turn then the vehicles within cluster, vehicles in the cluster shaded with cross lines and the vehicles oncoming are to be alerted.

2. **Brakes, Road Blocks, Slippery Roads, Wrong Way Vehicles**:



All the messages above comes under the same reaction list as all these messages are intended to the vehicles coming from behind. Same reaction will be expected from all the vehicles. If a vehicle in cluster A invokes the message the receipients would be from cluster A and Cluster B. The vehicles in the cluster B are affected without any cross verification. But the vehicle in cluster A has to check with the GPS Details whether the message received is from vehicle coming from behind it or ahead.

3. **Ambulance alert:**

An ambulance alert can be raised by an ambulance (or even any other vehicle nearby if there is no alert facility in the ambulance). This alert is not for vehicles coming from behind but for vehicles moving in the front for leaving way to ambulance.

Distance Measurement using GPS.

As we need distance calculation between two vehicles which are need to be processed alerts will be within one kilometre range, and the exact measurement of distance is not a key, so we can use Haversine formula, which calculates direct distance between two geographical points, ignoring the geographical structures like hills, flyovers etc.

A vehicle that receives the alert may check for distance between itself and vehicle that raised alert.

Consider GPS position of vehicle raising alarm (lt1, ln1), and the GPS position of current vehicle to be (lt2, ln2).

Then haversian value will be:

$a= [\sin((\text{radian}(lt2)-\text{radian}(lt1))/2)]^2 + \cos(\text{radian}(lt1))* \cos(\text{radian}(lt2))* [\sin((\text{radian}(ln2)-\text{radian}(ln1))/2)]^2$

then distance between two vehicles will be

$d=2*R*\text{atan2}(\text{sqrt}(a),\text{sqrt}(1-a))$

where R is earths Radius=6371000meters

The distance measurement formula used here will calculate radial or bird view distance between two points without considering turns in the road. The algorithm must be applied along with turns in the maps to find the exact distance required to travel.

Advantages of Clustering location based:

- Abolition of cluster head; if the cluster head changes its moving path all other vehicles are left clueless and again need for identifying a cluster head is overhead for vehicles. Location based clustering abolishes requirement of cluster head.
- Scalable: location based clustering gives communication technology to use cellular-IoT.
- Easily adoptable, construction of clusters based on connecting tower location makes the system easily adoptable as most of the infrastructure required will be already established by mobile networks.

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- Predefined receivers: formation of cluster based on location brings all the vehicles to be alerted under limited no of clusters, so the recipients can be communicated with multicast.
- Avoid unnecessary traffic: using of multicast to communicate the alerts will bring down network overhead drastically where as we may had to use broadcasting otherwise, and still we would not be sure that all the recipients received the alert or not.
- Power consumption: when most of the operations such as querying of vehicles from other cluster, updating database message etc are all managed by tower itself or a server connected to the tower, the power consumption required by the vehicle is reduced by a maximum factor.
- Simplicity: location based clustering fits into the existing cellular network infrastructure as it is like a cellular network so establishing networks or communicating etc. are very simple.

Disadvantages:

- As on today very few of the mobile operators have announced support for cellular IoT. And the developments are on the way.
- Location based clustering makes very frequent changes in the members of the cluster as vehicles enters and moves out rapidly. (however a vehicle may be in the database until it moves out of 3rd cluster.

4. SUMMARY AND FUTURE WORK

With the advent of cellular IoT and position based clustering we can achieve more convienient, simple and efficient architecture for VANETs.

Use of cellular IoT will make things very simple and the vehicles may be clustered by means of a central server and the same list will be communicated to all the vehicles in the cluster. As the vehicle is expected to remain in the cluster for atleast 5-10 minutes the vehicle need not to query cluster member frequently.

Very importantly we can extend this model to collision detection system based on the GPS positions, movement direction, and speed of the vehicle. But for this we need very high accurate GPS system with dimension of vehicle etc.

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