State of the Art of Data Dissemination in VANETs

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***Abstract*— In VANETs (Vehicular Ad-hoc NETworks), RSUs (Road Side Units) and vehicles disseminate safety and non safety messages. The aim of VANETs is to enable dissemination of traffic information and road conditions as detected by independently moving vehicles. For VANETs applications, it is important to disseminate data from an information source vehicle to many destination vehicles on the road. Dissemination of data in VANETs is used to improve the quality of driving in terms of time, distance, and safety. In this paper, a solution of ensuring data dissemination in vehicular ad-hoc networks for sparse and dense vehicular network is presented. Architecture for data dissemination is also proposed.**

***Index Terms*— VANETs, DSRC, Data dissemination, RSU.**

I. Introduction

Data dissemination in VANETs can be used to inform drivers or vehicles for traffic jams and to propagate emergency warning among the vehicles (incident or accident) to avoid collisions. In India alone, there are around 400,000 road accidents with 90,000 fatal accidents [1]. Indian roads struggle with problems of traffic flow and instability. We can save lots of lives, money, and time by forewarning appropriate information to the driver or vehicle regarding congestion and traffic management. Numbers of innovations in safety, comfort, and convenience have already made today's vehicle a very different machine than it was in the past days. Now a new technology characterized by proliferation of low-cost wireless connectivity and distributed peer-to-peer cooperative systems, is changing the way in which next generation vehicle will evolve. So data dissemination in VANETs plays important role for safety and non-safety application. VANETs are based on short-range wireless communication. The Federal Communications Commission (FCC) has recently allocated 75 MHz in the 5.9 GHz band for licensed Dedicated Short Range Communication (DSRC) [2]. VANETs can be divided into two main areas: Safety applications (e.g. collision warning and work zone warning) and non-safety applications (e.g. traffic condition application and comfort application). For an example, if the vehicle has crashed on the highway, the emergency information can be propagated as soon as possible to inform the vehicles behind the accident for the purpose of safety of other vehicles, might be caused due to this accident. The second area receiving direct benefit is relevant to transportation traffic control. The immediate benefit from VANET is to improve the efficiency of traffic system.

Information about traffic jam can be acquired in real-time so that drivers heading towards the congested area can receive it with sufficient time to choose alternate routes. Toll roads can be automatically paid without the installation of additional hardware to a vehicle. Traffic signals equipped with communication equipment can be used to more accurately control intersection traffic. Now non-safety applications, for example if a gourmand can easily find some suitable restaurants by using the location based service through VANETs and also useful local advertisements and announcements can be delivered to travelers, such as sale information at a departmental store, the available parking lot at a parking place, the room availability and price at a hotel, the menu at a restaurant. With the rapid applications of VANETs, especially for the safety applications, it may be time dependent. Thus, the information must be sent to other vehicle quickly. For the information dissemination in VANETs, we have to consider the different scenarios or different communication patterns. Node mobility, extreme network density and changing topology from urban gridlock to rural traffic and the rapidly changing information needs moving vehicles make VANETs harsh and demanding networks. We consider the problem of data dissemination in VANETs, where (1) the vehicular network consists of a multitude of data sources and data users; each vehicle is potentially a data source and user at the same time and (2) diverse types of applications, such as traffic management, situational awareness, and commercial services share the same networking infrastructure (RSUs etc.). The aim of data dissemination is to maximum utilize network resources to serve the data needs of all users. Each vehicle participating in the VANETs periodically produces reports regarding the traffic condition. In this paper, we discuss the solutions proposed for ensuring data dissemination in vehicular ad-hoc networks for sparse and dense vehicular networks and also proposed a suitable and needful architecture for data dissemination.

The rest of the paper is organized as follows. Section II contains challenges in data dissemination in VANETs. In section III, data dissemination in VANETs is presented. Related work is discussed in Section IV and data dissemination in VANETs mechanism is proposed in section V and conclusion in section VI.

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II. Challenges In Data Dissemination In VANETs

The most important challenges in VANETs are high mobility and frequently disconnected topology at different parts of metropolitan area. Some vehicles move on the road at the speed of less than 10 km per hour in a traffic jam condition, while others move at over 80 to 100 km per hour on highways. The traffic density is low in suburban areas and during night, on the other hand, the network node density is usually extremely high in downtown areas during rush hours in day time, which may result in frequent network disconnections. Thus the correct approach for data dissemination in VANETs needs to consider the network diversity and adapt the dissemination mechanism according to the different network environments. Because of the diversity, there is no simple 'one-for-all' solution for disseminating data to all recipients spreading across the metropolitan. In order to disseminate data to a far away vehicle, the data need to be forwarded over multi hops, spanning a large geographic area. The data delivery in the presence of disconnections or sparse network becomes the most eminent problem. When the target vehicle moves closer to the roadside unit and is located in a vehicle densely populated area, disconnection is of less concern. Instead, it becomes the major problem when many vehicles close to one another are requesting data at the same time, and sharing same wireless media. Therefore usage of limited bandwidth becomes the key issue. When a vehicle moves within the one-hop range of the roadside units, data can be delivered to the vehicle at the highest throughput. However, the vehicle only stays in the one-hop coverage of the roadside unit for very short time while it is moving. Thus, as a vehicle passes by the roadside unit, it is most desirable to extend the connection time between the vehicle and the roadside unit so as to disseminate more data. For more efficient data dissemination, multiple roadside units can be wirelessly connected together to form an infrastructure mesh network and cooperatively disseminate data to vehicles. Then how to distribute the data over the mesh nodes is an important issue. In addition to diversity, several other unique properties further complicate the data dissemination in VANETs, which have never been considered in other types of ad hoc networks. Vehicles generally move at high speed than nodes in other kinds of MANETs, and the link topology changes rapidly [3], [4]. Many existing structures in the literature for efficient data dissemination, such as clustering, grid and tree are extremely hard to set up and maintain. Because of network diversity in both topology and mobility, the network can be sparse at some regions, which may result in frequent network disconnections and network partitions. In other areas where network node density is high, the conventional broadcast based mechanism for data dissemination may lead to broadcast storm [5]. In urban areas, roads are often separated by buildings and other obstacles which can block radio communication, so communication is often restricted along roads. The above challenges are unique to VANETs, particularly in large scale metropolitan. They have never been considered in designing data dissemination protocols for other forms of MANETs before, making the existing protocols insufficient to serve VANETs. It has been shown in [6],[7],[8],[9] that many traditional MANETs data dissemination schemes result in poor overall network performance in VANETs, such as long delay, low data delivery rate, low bandwidth utilization and high network overhead.

III. Data Dissemination In VANETs

The concept of data dissemination is wide and useful in VANETs. We generally refer to it as process of spreading data or information over distributed wireless networks, which is a superset of VANETs. The data dissemination approaches in this network may be classified on the basis of:

1) V2I /I2V dissemination
   a. *Push based*: In push based data dissemination, the data can be efficiently delivered from moving vehicles or fixed base station (RSU) to another vehicle. This can be justified with traffic condition, e-advertisement etc.
   b. *Pull based*: Pull based data dissemination is the type where any vehicle is enabled to query information about specific location or target. This is one form of request and response model. In this type, enquiry about parking lot, nearby coffee shop etc. are the cases.
2) V2V dissemination
   a. *Flooding*: In flooding broadcast the data is created and received in vicinity. Generally every node participates in dissemination. This flooding approach is good for delay sensitive application and also very much suitable for sparse networks during low traffic conditions.
   b. *Relaying*: The relaying type of data dissemination in the network, the relay node is selected (next hop) where relay node forwards the data to the next hop and so on. The main advantage of this approach is it reduces congestion and it is scalable to dense networks. This is generally preferred for congested networks.

TABLE 1. Comparison of Data Dissemination approaches

Dissemination approach	**Pros**	**Cons**
Push based	Suitable for popular data	Not suitable for unpopular data
Pull based	Suitable for non-popular data, user specific data	Cross traffic incurs heavy interferences, collisions.
Flooding	Reliably and quickly distribute data	Not suitable for dense networks.
Relaying	Works well in dense networks	Selecting best next hop & reliability is difficult

When a vehicle is far away from the service roadside unit it may have to go through multiple hops over long distance to access the data on the roadside unit. However, data access through multi hop is much more difficult because VANET is highly mobile and sometimes sparse. It is difficult to find out the end-to-end connection for a sparsely connected network. VANETs on freeways or urban areas are more likely to form highly dense networks during bumper – to – bumper rush hour traffic, while VANETs are expected to experience frequent network fragmentation in sparsely populated rural freeways or during late night hours. We believe that the disconnected network problem is also a crucial research challenge for developing a reliable and efficient routing protocol that can support highly diverse network topologies. Network fragmentation is a fundamental routing issue that needs to be addressed in vehicular ad hoc networks research. Although it is very difficult to find an end-to-end connection for a sparsely connected network, the high mobility of vehicular networks introduces opportunities for mobile vehicles to connect with each other intermittently during moving [6]. In order to forward messages efficiently in dense network situations, the network protocols must manage contention for the bandwidth. Simple flooding of multi-hop messages can lead to the broadcast storm problem, in which collisions and message latency significantly increases with increases in node density. Previous research has addressed the broadcast storm problem by attempting to limit the nodes that forward the messages, for example, by limiting retransmission to nodes further from the source than the last hop. In existing literature, data dissemination models are described in two types in VANETs [10], [11]; the first is push model (communication in terms of broadcast nature) and second is pull model (communication in terms of on demand nature).

IV. Related Work

Namboodiri *et al.* [12] is presented connectivity between moving vehicles to set up a short path with few hops in a highway model. The paper is discussed two predication based protocols named as $PRAODV$ & $PRAODV-M$. Both of the protocols are variant of the ad-hoc on demand distance vector protocols [13]. In this scheme, uses the route on the basis of maximum prediction and before break the lifetime of the route (estimated value), send request to establish a new path by $PRAODV$ protocol. Assumption of this scheme is overhead on the network, not a major concern in VANETs.

In vehicular ad hoc network density depends on vehicles density, is highly variable. In traffic jam conditions, in a city center or highways at the entrance of big cities the network is categorized in very dense network while in sub urban traffic is a sparse network. So another data dissemination technique uses broadcast mechanism is discussed in [14]. The scheme is presented the cluster based method for data dissemination, where location based approach is used. But this scheme is unacceptable in low density of mobile ad hoc networks.

The other data dissemination scheme, opportunistic resource exchange for inter vehicular communication is proposed by Xu *et al.* [15]. This is the model for vehicles to exchange the information from its local database for example broadcasting a location for parking place to the vehicles. But limitation of this scheme is distance between two vehicles is smaller than the wireless transmission range and transmission range for vehicle to vehicle communication is recommended up-to 300 – 500 meters by DSRC [16],[17],[2]. Another limitation of this scheme is not capable of good performance with densely deployed network i.e. VANETs due to its MAC [16], [17] collisions.

Korkmaz *et al.* [18] is presented an urban multi-hop broadcast protocol to assist disseminate the data. The scheme is designed to address the issues such as broadcast storm, hidden node, and reliability of multi-hop broadcast especially in urban areas. In this scheme, only one vehicle is used to forward and acknowledge the broadcast packet. This assumption is taken for mitigation of broadcast storm problem and on the other hand this scheme is not able to provide solution in network congestion. Apart from those schemes, to mitigate the problem of scalability, loop free routing, dynamic topology maintenance (i.e. dynamic adaption of routing information in highly mobile topology), minimal control overhead, low complexity and other multicast capabilities; some other solutions are presented in the form of routing protocol are discussed below.

Karp *et al.* [19] proposed Greedy Perimeter Stateless Routing for wireless networks (GPSR) utilizes the strategy of greedy forwarding of messages toward a known destination. If, at any hop, there are no nodes in the direction of the destination, then GPSR has a recovery strategy called perimeter mode that routes around this void. However, GPSR work well in static ad hoc networks (e.g. sensor networks) but they did not consider the impact of high mobility. So this protocol is inefficient and not suitable for high mobile network e.g. VANETs.

Mo *et al.*[20] addressed the most important challenges of VANETs communication like high mobility and frequent link disconnection due to many reasons explained earlier. To overcome these challenges multi-hop on demand routing protocol intended to find robust paths in urban areas. The proposed scheme is also known as **mu**lti-hop **r**outing protocol for **u**rban vehicular ad hoc networks (MURU). The proposed protocol tries to minimize the probability of path breakage by exploiting mobility information of each vehicle and by using a special parameter called expected disconnection degree factor to select the most robust path from source to destination. The scheme is fully distributed location-based routing protocol and used to assume expected disconnection degree to select the most stable path from source vehicle to destination vehicle. However, this assumption is unfit in highway scenarios when traffic decomposes into disconnected clusters.

The position based routing scheme [21] based on microscopic model is proposed by Naumov *et al.* [22]. The scheme is known as Connectivity-Aware Routing (CAR) for inter-vehicle communication in a city and/or highway environment. CAR protocol was developed taking into consideration the fact that end to end connectivity is not guaranteed in vehicular ad hoc networks. The main theme of connectivity aware protocol is to try finding a connected path between the source and destination even if it is not the shortest path. This is being done using a route discovery process before the real data can be sent. This is because the current shortest path may experience lack of connectivity later while the longer one is fully connected.

GVGrid [23] is a position-based routing protocol that constructs a route from a static source node to vehicles that may exist in a destination region. This protocol is also a variant of on-demand protocol. It also maintains the route when it breaks because of vehicle mobility. GVGrid protocol tries to discover path on the bases of vehicle mobility characteristics, where a route that is expected to achieve best stability. In this protocol, geographical area is subdivided into uniform squares, known as grid. Every vehicle knows in advance its geographical positions and direction through digital map, which is equipped with each vehicle. GVGrid achieves stability to find the network from digital map. This protocol achieves the stability of route by vehicles which are moving with same speeds and in the same directions.

In [24], a position based routing protocol is discussed where packet forwarding decisions are made based on power awareness. The basic routing strategy is a variant of greedy forwarding scheme. In this scheme the next hop is selected to be the vehicle closest to the destination. While this strategy is correct, it may lead to unnecessary forwarding and, ultimately, to wasted bandwidth. GyTAR [25] is another greedy routing protocol for city environments. It focuses on selecting the best street intersection to route a message as part of data dissemination. Between two intersections, GyTAR chooses the next hop, in a greedy fashion to be the closest vehicle to the destination. However, choosing the closest vehicle as next hop may lead to significant overhead. Further a moving vehicle can carry the packet and forward it to the next vehicle.

Little *et al.* [26], proposed directional propagation protocol (DPP) utilizes the directionality of data and vehicles for packet propagation. DPP considers real traffic scenarios in which vehicles form clusters on the road and these clusters may be disconnected from each other. The proposed scheme uses co-directional clusters where clusters that runs in the same direction as the packets to deliver to the next vehicle. When disconnection occurs between two co directional clusters, clusters in the opposite direction are used as bridges to the next co-directional cluster. The proposed scheme is likely to waste significant bandwidth because of uneven traffic density as well as imposing delays on packets propagation. Agarwal *et al* [27] presented an analytical model for DPP in which the expected distance between clusters, the expected disconnection time and the effective propagation rate were computed. However, the proposed algorithm does not explain why traffic clustering is inherent to VANETs.

Abuelela *et al.* [28] presented an opportunistic packet relaying in disconnected vehicular ad hoc networks, OPERA, uses both traffic directions to disseminate packets in an efficient way. This protocol is a hybrid protocol and used to reduce delays and bandwidth as proactive routing and data mulling. For this, OPERA uses clustering techniques and use the traffic incoming direction to disseminate a packet only if it overlaps another co directional cluster on the road. Limitation of these schemes is such as OPERA as well as DPP were designed for undivided roads at which cars in both directions can communication with each other.

Zhao et al. [29] address the issues high mobility and frequently disconnection of VANETs and provide the solution of carry and forward through several vehicle assisted data delivery protocols like as; L-VADD, D-VADD, MD-VADD and H-VADD based on the techniques used for road selection at the intersection. The basic idea is through carry and forward, the message can be delivered to the destination without an end-to-end connection. Where nodes carry the packet when routes do not exist, and forward the packet to the new receiver that moves into its cluster or communication range. In this protocol, dynamic path selection should continuously be executed throughout the packet forwarding process.

V. The Proposed Data Dissemination Technique

A. Basic Idea

To illustrate the basic idea of this proposed technique, consider a multilane two way highway scenario depicted in figure 1. In this proposed idea, we divide the highway into clusters and these clusters are made according to the road side unit. The particular area, to which any roadside unit can broadcast the information (for that geographical area) on the highway, forms a cluster, which we will cover in next section Cluster Formation and Maintenance. Safety message can be broadcasted within different clusters from roadside units. As all the modern cars are enabled with GPS systems, so it is very easy for satellite to access information about position, speed, location and distance from roadside unit. There are two kind of information, first one is instant or emergency warning message and second one is simple communication among vehicles.

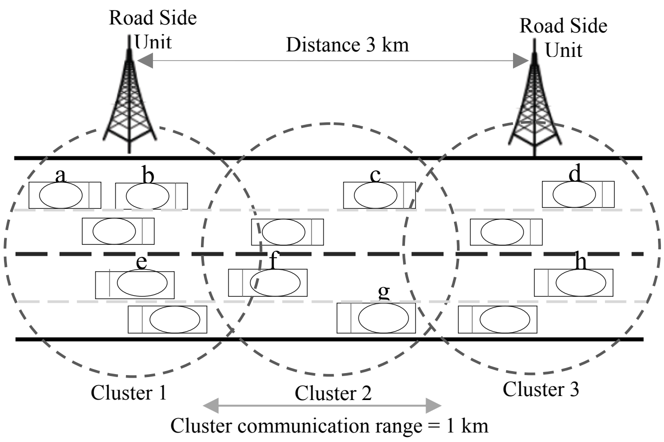

Fig. 1. The proposed architecture

We are considering a scenario where, by using the roadside units we want to transmit information about any emergency. If there is no vehicle in other lane within the same cluster (which is mainly responsible) to propagate the information which is shown in figure 2, we used roadside units which transmit information timely and accurately. This is a situation where network is sparse. This architecture is for both scenarios, Vehicle to Vehicle (V2V) as well as Vehicle to Infrastructure (V2I). The emergency message will be communicated through vehicle to vehicle in a multi-hop fashion and road side unit will work when there are no or less number of vehicles for message propagation.

The basic working of this proposed technique is, assume that car a wants to communicate to car d as shown in figure 1. The car message format will be like this [$a.speed$, $a.position$, timestamp] because as we proposed the highway is divided in clusters so in that case when a packet is generated from any lane then it will spread over in the cluster.

Each cluster will cover both ways lane. So the generated packet will propagate through another lane car which is running at fastest speed. Otherwise if all car from another cluster and lane are running at same speed, then packet can be propagated in a multi hop fashion, and now in multi hop the packet will go through cars e, f, and g. When packet will reach to car h, that time it will again be in new cluster . In that cluster packet will be send to the intended destination as a single hop manner.

B. Cluster formation and maintenance

As already discussed earlier, cluster formation is done according to roadside unit coverage. In each cluster each car maintains it's $car.speed$ and $car.position$. This information is shared by the roadside unit, which will decide according to speed which car will carry the packets to the destination. Each cluster information is used by the roadside unit because each time every car will change their cluster so that information should be updated in roadside unit time to time. This cluster maintenance should not be hard to perform as cars will have correct information about their clusters most of the time.

C. Car to car communication

As shown in figure 1, car to car communication is done when any car wants to communicate to any other car. For example if any accident is there on the roadside, then the message to slowdown speed and or to choose the alternate route, will be in multi hop fashion and the message format will be $[a.speed,\ a.position,\ timestamp]$.

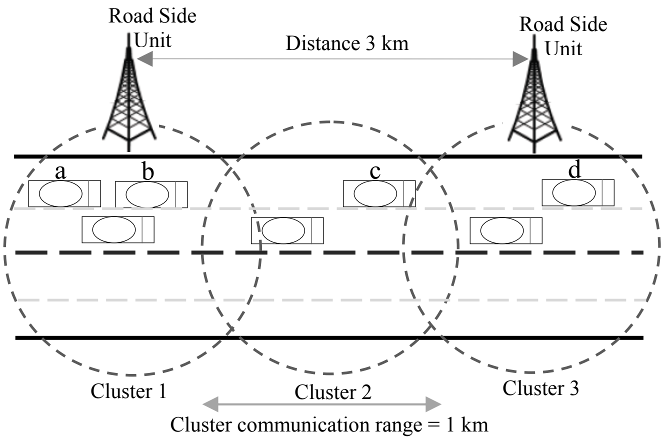

Fig. 2. When there is no vehicle in opposite lane within same cluster

When any car enters a new cluster, at that time a hello message is sent to every car of that cluster. Each car should have the information about its current cluster. When a car wants to communicate, the message will go in multi hop fashion in backward and forward directions. If the message is emergency warning message, that time the message will propagate through the fastest car within the cluster. The fastest car will always hold the packets and will broadcast them to all cars within the cluster it passes through. This feature is extremely useful for accident notification and for alerting drivers approaching an accident of the corresponding slow down.

D. Road side infrastructure to car communication

Each time when a car will enter into the cluster its road side unit will communicate to this car. It will add new car information like car speed, car position, moving direction etc. This information will help the road side unit to broadcast the emergency information to the cars. Every minute so many cars will leave and enter the cluster with high speed. Roadside units will communicate to cars as soon as they enter their cluster, because for example if there are no cars with in a cluster and there is an accident or emergency message, that time as soon as any car enter the cluster, message will propagate through the first entered vehicle in that cluster. This roadside units communication is only helping communication when there is no vehicle in cluster range otherwise vehicle communication is possible very easily.

VI. Conclusion

In this paper, we have presented the challenges in data dissemination in vehicular networks, existing mechanism of data dissemination and proposed approach for data dissemination for highway scenarios for vehicular networks. We have used roadside units, and clusters formation in the proposed approach. In the proposed architecture V2V and V2I communication was done according to information priority. We have also proposed the architecture for data dissemination in VANETs. The main advantage of using roadside units in our approach is to achieve low latency communication within vehicles and it can be extended in terms of their connectivity. This approach is also useful for distributing time critical data. Currently our analysis and proposed ideas are based on assumptions of two lane highway and it can further be extended for other possibilities.

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