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# A Survey on Data Dissemination Scheme for Location-Dependent Data in VANETs

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***Abstract*****—** The infrastructure of vehicular networks plays a major role in realizing the full potential of vehicular communications. More and more vehicles are connected to the Internet and to each other, driving new technological transformations in a multidisciplinary way. Researchers in automotive/telecom industries and academia are joining their effort to provide their visions and solutions to increasingly complex transportation systems, also envisioning an innumerable of applications to improve the driving experience and the mobility. These trends pretense significant challenges to the communication systems: low latency, higher throughput, and increased reliability have to be granted by the wireless access technologies and by a suitable (possibly dedicated) infrastructure. In this paper presents an in-depth survey of more than ten years of research on infrastructures, wireless access technologies and techniques, and deployment that make vehicular connectivity available. In addition, here identify the limitations of present technologies and infrastructures and the challenges associated with such infrastructure-based vehicular communications, also highlighting potential solutions.

***Keywords*****—** Data dissemination, location-dependent, VANETs

## I. INTRODUCTION

If a driver can visually be acquainted with the current circumstances of roads on a route to destination, such as traffic jams, roadwork, accidents, and beautiful sights, it may select a better (faster, easier, or more fun) route to the destination. Currently, there are some applications that inform a driver of traffic information to make driving more comfortable, such as Google maps and ETC2.0 [1] in Japan, etc. In addition, Pioneer has provided a cellular network-based system that allows a driver to visually know the current circumstances of roads predefined by the system [2]. However, to the best of our knowledge, there is no application that visually informs a driver of the current circumstances of roads Ishihara et al. proposed a Vehicular Ad-hoc NETworks (VANET)-based road traffic information sharing system, called the Real-Time Visual Car Navigation System [3–5]. This system allows driver to obtain photographs/videos of Point of Interest (PoI) that is inputted to an onboard device, e.g., a car navigation device. In this system, when a driver inputs of PoI to an onboard device, the vehicle sends a request message to vehicles in the vicinity of the PoI. Then, vehicles that have a photograph/video of the PoI send it to the requesting vehicle.

Overview of the Research in Infrastructure-Based Vehicular Networks. In the context of vehicular networks, infrastructure is a set of specialized communication devices supporting the network operation. Common properties include (but are not restricted to) network centrality, communication bandwidth, storage space, and high availability. Because vehicular network devices are initially envisioned to be located at roadsides, they are commonly referred to as RSUs and may provide a large number of functions, such as the following:

(i) Broadcast
(ii) Channel allocation
(iii) Caching
(iv) Content download
(v) Data dissemination
(vi) Data aggregation
(vii) Data scheduling
(viii) Gaming & streaming
(ix) Gateway
(x) Hand-off
(xi) Vehicles localization
(xii) QoS
(xiii) Real-time support
(xiv) Routing
(xv) Security
(xvi) Multihop comm

 

## II. Literature Review

In [8], Grassi et al. proposed Navigo, an interest forwarding scheme in NDN. In Navigo, each vehicle that has received or generated an interest forwards it based on the shortest path between the locations where it exists and the location where many vehicles having the demanded data exist. This scheme aims to deliver interests to locations where many vehicles having the required data are. In Navigo, vehicles send requests (interests) to many vehicles having the required data by sending the requests to the locations of these vehicles. In the Dmap-based scheme, vehicles register their requests to their Dmap instead of sending requests to the Point of Interests(PoIs). In addition, vehicles having LDI can know not only a request for the LDI, but also the geographical distribution of the strength of demands for the LDI, and utilize this information for efficiently routing the LDI.

In [9], Ahmed et al. proposed CODIE as a data dissemination scheme using NDN. In CODIE, vehicles that forward an interest append the hop count of the interest from the requesting vehicle, and vehicles having the required data forward the data in accordance with the hop count. In this scheme, the same LDI may be disseminated to the same region at the same time, and network resources may be wasted. On the other hand, in the Dmap-based scheme, each vehicle grasps regions where each LDI is highly desired as well as its distribution. Therefore vehicles may be able to disseminate demanded LDI to many vehicles with a small number of the LDI transfers. In addition, Bian et al. introduced the NDN architecture to VANETs and proposed forwarding and caching schemes [10].

Dmap-based data dissemination proposed in [4] and [17] can be categorized into a kind of data dissemination system for sharing Location-Dependent Information (LDI) in VANETs. Traffic information is typical LDI treated in VANETs. Various applications for sharing traffic information in VANETs, such as SOTIS [18], Trafficview[19], CASCADE [20], and Zone Flooding [21] have been proposed so far. They have a function for aggregating LDI obtained in a distributed manner. For example, in SOTIS, vehicles periodically broadcast a packet including traffic information, e.g. their location, velocity, and direction. When a vehicle receives information from other vehicles, it aggregates all the known information on each road segment to one average value. In those applications, unneeded information may be sent because vehicles broadcast traffic information without considering how strongly the traffic information is required. On the other hand, Dmap-based data dissemination aims to reduce redundant information dissemination by disseminating strongly required information in accordance with a Dmap.

In this work, a Dmap is represented with soft-state sketches proposed in [22]. A soft-state sketch is a data structure to stochastically estimate the number of unique data for aggregating data and reducing communication traffic. A soft-state sketch is represented by an array of nonnegative values. In [22], soft-state sketches are used for counting the number of available parking spaces every load segment and sharing this information among vehicles. Vehicles use a set of soft-state sketches for estimating the number of available parking spaces in a load segment. In all vehicle has a set of soft-state sketches every load segment. When each vehicle finds available parking spaces, it inputs the initial TTL of available parking spaces information to a soft-state sketch corresponding to the load segment where the vehicle exists. In addition, vehicles append sets of soft-state sketches to a beacon that is sent periodically, and update their information by merging their own soft-state sketches with received ones.

On the other hand, in this paper, it is use soft-state sketches for counting the number of demands for LDI and sharing this information among vehicles. In our scheme, each vehicle has a set of soft-state sketches for every pair of each location where LDI is generated and each location where LDI is required. Then, each vehicle inputs the initial TTL to a soft-state sketch corresponding to its request when it requests LDI, and sends sets of soft state sketches as DMI with a beacon.

In[22], to reduce communication traffic for sending sets of soft-state sketches, a method for compressing soft-state sketches is proposed. However, here it is aim to reduce communication traffic by controlling the frequency of sending sets of soft-state sketches and selecting sets of soft-state sketches that vehicles should send.

Mershad et al. [14] propose ROAMER (ROAdside Units as MEssage Routers in VANETs) to exploit RSUs to route packets between any source and destination in vehicular networks. The basic motivation behind using RSUs to route packets is that RSUs are stationary. It is much easier to send a packet to a fixed near target than to a remote moving object. ROAMER forwards packets to multiple neighbors to increase the chances of reaching destination without significantly increasing the overall traffic. Authors evaluate the RSU backbone routing performance via the Ns-2 simulation platform and demonstrate the feasibility and efficiency of the scheme in terms of query delay, packet success delivery ratio, and total traffic.

Liang and Zhuang [22] propose roadside wireless local area networks (RS-WLANs) as a network infrastructure for data dissemination. More precisely, a two-level cooperative data dissemination approach is proposed. For the network level, the aim is to use available RS-WLANs to provide services to nomadic users. Packet level cooperation uses cooperative caching/transmission to improve the transmission rate: cooperative caching reduces the perception of limited bandwidth whereas cooperative transmission improves the packet transmission rate.

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Luan et al. [56] propose an infrastructure composed of roadside buffers, devices with limited buffer storage, and wireless connection to support the vehicular communication with the goal to reduce the costs of network deployment. In addition,

Mishra et al. [52] propose the use of stationary info-stations and moving vehicles in a publish-subscribe model. Vehicles may act as publishers, subscribers, or brokers. Every major crossing of city is equipped with stationary info-stations that act as ultimate place holders for publications and subscriptions.

Palazzi et al.[28,29] investigate an infrastructure for gaming over vehicular networks. They consider the problematic coexistence between TCP and UDP flows in the context of infrastructure-based vehicular networks. They observe that retransmissions of TCP are exacerbated in vehicular networks since the high mobility of vehicles generates continuous variations in the number and type of flows served by the infrastructure along the road. Thus, they propose the use of smart access points along roads, to be able to regulate heterogeneous transmission flows and make them coexist efficiently. Smart access points basically snoop transiting packets of various flows and computes the maximum data rate at which each elastic application will be able to transfer data without incurring in congestion losses. This data rate is computed and also included on the fly in transiting ACKs of TCP flows. They validate their strategy using the NS-2 simulator. Authors use a grid-like road network streaming the video StarWars IV in high-quality MPEG4 format. Online gaming traffic is inspired by real traces of the popular Counter Strike Action Game, and it has (i) a server-to-client flow characterized by an inter departing time of game updates of 200 bytes every 50ms and (ii) a client-to-server flow of 42 bytes every 60ms.

Marfia et al. [57] exploit the use of public Wi-Fi access points to provide vehicular communication. Authorsmap the public access points available in the city of Portland (US) and vehicles can opportunistically use the infrastructure to communicate with other vehicles in order to avoid long wireless ad hoc paths and to alleviate congestion in the wireless grid. Analytic and simulation models are used to optimize the communications and networking strategies. Authors conclude that the motion model has enormous impact on the results and that the presence of infrastructure largely improves the communication. When the community focuses on the shortness of contact time between vehicles and infrastructure, it becomes clear that scheduling algorithms should consider the data size and deadline or even employ broadcasting to serve a large number of requests.

Zhang et al. [58] propose a scheduling scheme for RSUs to provide a balance between serving downloads and upload requests from fast-moving vehicles on highways. The infrastructure acts as routers to Internet access. Although the Internet connection proves to be of great value for drivers, the deployment and maintenance costs of the infrastructure are considered very high. Thus, the authors propose the deployment of cheap RSUs acting as buffers between vehicles.

Ormont et al. [74] mounted a testbed in the city of Madison, Wisconsin, to monitor Wi-Fi signals over the city. The main communication channel is the 3G cellular network. Clients were installed in two buses. Each city bus operates on multiple routes on a single day and is, therefore, able to traverse through significant parts of the city. Buses provide Internet access to passengers through 3G connection. A client is a laptop with a Wi-Fi interface running software that monitors and stores Wi-Fi networks found. Cellular interface provides continuous remote access to each testbed node to experimenters. A client node uses it to periodically upload measurement data to a back-end database system. Authors argue that such testbed can be used to draw coverage maps, analyze performance at specific locations, infer mobility patterns, and study relationships between performance and mobility.

Ruiz et al. [46] study the handover using WiMAX (IEEE 802.16; http://wirelessman.org/) and Wi-Fi applied to vehicular communication. They have mounted a testbed in the Campus of Espinardo, University of Murcia. Campus has a ring road that surrounds a huge enough building area. Any vehicle connected to the wireless network can freely move, using different access points that could be available throughout its path. These access points could belong to different domains and different wireless technologies like Wi-Fi, WiMAX, and Universal Mobile Telecommunication System (UMTS) (http://www.protocols.com/pbook/umts.htm). As a consequence of this, several types of handovers can be differentiated:

Annese et al. [44] study the vehicle-to-infrastructure communication to provide UDP-based multimedia streams. The work considers continuous coverage by the infrastructure within the urban road topology and analyzes the vehicular communication as a mesh network [148]. Mesh networks are typically free-standing robust systems that can be conveniently integrated with the existing infrastructure and offer high bit rate services. Authors do not assume vehicles as end nodes (such as those proposed in [31–33,73]), but as mesh nodes connecting the wireless medium and acting as routers. They argue that such new point of view is important because it allows the routing protocol to run on the mobile node itself, better adapting to the high-mobility profile of the node. The vehicle becomes a mobile hot spot that can act as a gateway towards the mesh infrastructure.

Because of the high investments required to deploy RSUs in large cities, Tonguz and Viriyasitavat[53] propose an alternative approach to roadside infrastructure by leveraging the use of existing DSRC-equipped vehicles to provide RSU's functionality. The approach employs a self-organizing network paradigm and draws its inspiration from social biological colonies such as ants, bees, birds, and fishes. Such approach was formulated for the first time by Tonguz [94]. Vehicles acting as temporary RSUs must make brief stops during which they act as communication bridges for other vehicles in the network. Each vehicle runs the distributed gift-wrapping algorithm proposed by Viriyasitavat et al. [20]. Upon receiving a message, the vehicle determines whether it lies on the boundary of a coverage polygon. As a drawback, vehicles acting as temporary RSUs need to make brief stops (approximately 30 s) to reach the maximum number of uninformed vehicles. Authors argue that such increase in travel time is small when compared to increases due to accident-induced congestion. Finally, Sommer et al. [54] propose utilizing parked vehicles as relay nodes to address the disconnected network problem. Extensive simulations and real life experiments show that parked cars can increase cooperative awareness by over 40%.

Korkmaz et al. [63] propose a cross-layer multihop data delivery protocol with fairness guarantees where vehicles do not communicate with RSUs individually, but through one leader. The goal is to reduce the network traffic and to use bandwidth more efficiently. The leader will collect all information from other nodes and share it with RSUs.

Korkmaz et al. [40] propose a new protocol that employs fixed gateways along the road which perform periodic admission control and scheduling decisions for the packet traffic in their service area. The most important contribution of the protocol is providing delay bounded throughput guarantees for soft real-time traffic, which is an important challenge especially for a mobile multihop network. After the demands of the soft real-time traffic are met, the protocol supports the best-effort traffic using remaining bandwidth.

Ramani and Savage [31] propose SyncScan to continuously track nearby base stations by synchronizing short listening periods at the client with periodic transmissions from each base station. Brik et al. [32] propose MultiScan so that nodes rely on using their (potentially idle) second wireless interface to opportunistically scan and preassociate with alternate access points and eventually seamlessly hand-off ongoing connections.

## III. Simulation Studies

Each of the protocols studied in this thesis is compiled as part of the ns-2 simulator for the studies on the performance of that protocol.

## IV. Our Proposed Directions

Vehicular ad hoc networks (VANETs) are created by applying the principles of mobile ad hoc networks (MANETs) - the spontaneous creation of a wireless network for data exchange – to the domain of vehicles. The scope of the research work can be moved towards the comparison of TONSRP against other proposed routing protocols in an attempt to further support with certificate and message signature authentication acceleration. More and More intelligent on-board applications may store lots of personal information and vehicular data, which can be disseminated to multihop neighbours in Vehicular Adhoc Networks(VANESTs). Due to the requirement of continuous awareness of the road ahead, safety applications are still the key research trend in the mobile vehicular environment.

## V. Performance Metrics

The different metrics used for evaluating the performance of routing protocols in other VANET studies are used in this work also. They are Packet Delivery Ratio (PDR), End-to-End Delay (EED), Normalized Routing Load (NRL) and Average Hop Count(AHC). These four performance metrics are used for the evaluation of all the protocols studied in this work.

(i) Packet Delivery Ratio (PDR): It is calculated by dividing the number of packets received by the destination by the number of packets originated by the application layer of the source. The better the Packet Delivery Ratio, the more complete and correct is the routing protocol.

(ii) End-to-End Delay (EED): It indicates average end-to-end delay experienced by packets from when a packet is sent by the source node until it is received by the destination node. This includes the route discovery time, the queuing delay at nodes, the retransmission delay at the MAC (Medium ACcess)layer, and the propagation and transfer time in the wireless channel.

(iii) Normalized Routing Load (NRL): It is the total number of routing packets divided by total number of delivered data packets. This metric provides an indication of the extra bandwidth consumed by overhead to deliver data traffic. It is crucial as the size of routing packets may vary. The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the data packets. It is an important measure for the scalability of a protocol. NRL determines how a protocol will function in congested or low-bandwidth situations.

(iv) Average Hop Count (AHC): It refers to the average number of hops that the packets need to reach their destination.

Each value of V-max is used as input to the IMPORTANT traffic generator to generate a vehicular mobility pattern trace file corresponding to that value of V-max. Each such vehicular mobility pattern trace file is used as the node movement file that is input to ns-2. Each of ten different traffic connection pattern files generated by the CBR data traffic generator (using ten different seed values for random number generation) is used along with this node movement file as input to ten different simulation runs of ns-2. Thus ten different network simulation trace files are generated as the output of ten different simulation runs of ns-2 for each value of V-max.

Perl scripts are used to parse the network simulation trace file that is output by ns-2, and calculate each performance metric. The value of each performance metric is calculated from each of these ten network simulation trace files, and the average is taken for each performance metric. Graphs are then plotted for each performance metric against the varying maximum velocities, by using the average of the values from the ten simulation runs.

## VI. PROBLEM STATEMENT

This research focuses on the following problems of message propagation in VANETs:

### *(a) Problems with Message Propagation*

As discussed above, VANET messages are classified into safety oriented and service oriented messages. These messages could be propagated through two types of communications namely Vehicle-to-Infrastructure (V2I), where messages are exchanged between vehicles with the help of fixed infrastructure and Vehicle-to-Vehicle (V2V) communications, where intermediate nodes forward the messages from a source to an intended destination. Yet, depending on fixed infrastructure all the time for message propagation entails a great deal of investment in V2V communication. Also, a single point failure of such infrastructure may lead to hazardous and undesirable situations [21]. Though there are few solutions [19, 22, 23] proposed to support message propagation without the support of fixed infrastructures, achieving robustness (which means 100% packet delivery to intended receivers within certain time limit and acceptable overhead) in different network scenarios is still a challenging task in VANETs [19], due to the high mobility of vehicles.

More importantly, safety messages such as accident ahead, traffic jam, road damage, etc are the primary objective of vehicular ad hoc networks, introduced to improve road safety. Such safety messages need to be transmitted only in a small radius, but with stringent reliability and delay requirements. In other words, the delay requirements on emergency message delivery and the geographical areas with in which the data needs to be cooperatively collected and distributed pose design challenges. For example, by the time of an unexpected event, such as a traffic accident, it is important for all vehicles residing in the surrounding area to be notified of the hazard as quick as possible in order to avoid chain of accidents and to take appropriate safety measures. Though some existing protocols [22, 23] address this issue, the unique characteristics of VANET such as dynamic and unbounded nature, vehicle density, high Mobility of the vehicles imposes challenges to the existing message dissemination protocols to efficiently deliver messages under varying traffic scenarios.

On the other hand, service oriented data propagation between vehicles is equally challenging, as it requires routing between a source and a destination with real-time vehicular traffic information to make the communication fast and consistent. Different categories of routing protocols fall under two broad categories namely, proactive and reactive algorithms. Proactive algorithms work based on historical route information that are exchanged at predefined intervals. These algorithms [22, 25] suffer from excessive control overhead for route maintenance, which limits the routing performance. Different from proactive routing, reactive routing creates routes on-demand. Though these algorithms [26, 27] reduce the above control overheads, they are prone to frequent disconnection and re-routing that increases the average end-to-end delay.

Thus, in both categories, applications share the challenges raised by the continual variation in density and predominant intermittent connectivity between vehicles. Especially, in infrastructure-less vehicular communication, messages have to be carried to a distances of several kilometers by vehicles in a multi-hop fashion in variable density traffic conditions. This density variation can significantly affect the time taken to deliver the message. High traffic densities usually lead to smaller delivery times due to higher probabilities of the network being connected from source to destination. Of course, very high traffic densities can cause delays due to the network congestion. The large number of message exchanges between cars in dense traffic can cause overloading of the available network resources and lead to congestion related delays. On the other hand, low traffic densities often cause the network to be intermittently connected. In such cases, the message delivery speed is bottlenecked, which could even reach zero in case of a more prolonged network disconnection. These phenomena significantly degrade the performance of data dissemination strategies whether these are routing protocols or broadcast-based schemes [28].

However, the above discussed delays can be avoided by suitable message dissemination protocols. Hence, this thesis focuses on the aforementioned problems in message dissemination and concentrates on the development of data disseminating solutions that address these challenges while fulfilling the requirements of both safety and non-safety applications.

***(b) Problems with Node Selfishness***

Although proposing robust and reliable message dissemination algorithms can achieve betterment in message dissemination, it is possible if and if only all the nodes participate selflessly and cooperatively in the network. More preciously, message dissemination in VANET requires autonomous devices (OBUs) to route packets, which imposes many security challenges in the practical implementation of the networks. Most existing works [16–18, 20, 28, 29] assumes that all the nodes that make up a multi-hop network are willing to relay data, generated by other nodes. This assumption is reasonable in disaster recovery or military applications since the nodes have a common goal. However, it may not hold for civilian applications where each node aims to maximize its own benefits (like utilizing more bandwidth for sending and receiving its own data) from the network. In addition, vehicles might not cooperate when they do not benefit from their cooperation which consumes their valuable resources such as bandwidth, energy, and computing power. In civilian applications, selfish nodes will not be voluntarily interested in cooperation without sufficient incentive. But, they use the honest nodes to relay their packets without any contribution to the network. This behavior causes fairness, performance and security problems in the network. [30].

The above shortcoming can be rectified by activity-monitoring schemes, where one node monitors the performance of the other node. This objective can be achieved better in a cluster based environment, where cluster-heads can have more control on other nodes, for example monitoring their performance and to provide equivalent compensations, agreed by the network entities. However, clustering in VANET is not an easy task, as ensuring stability is the major challenge for clustering algorithms especially in a highly dynamic environment. Many VANET clustering algorithms lack a technique to capture the mobility characteristics of VANET nodes and fall in a major drawback of unstable clusters. With unstable clusters, the message dissemination and node cooperation protocols might perform worse than normal, since change of clusters impose lot of additional overheads in the network. Hence, this thesis further extends message dissemination with better node cooperation protocol under a high stable clustering environment.

## VII. RESEARCH OBJECTIVES

The main objective of this thesis is to study data dissemination solutions for vehicular environments that fulfill the specific requirements of both safety and non-safety/service-oriented applications. Although security and privacy are important issues to be considered during message dissemination, they are out of the scope of this thesis. Instead, we concentrate on scalable data dissemination solutions that work seamlessly in both sparse and dense vehicular networks. The scope of the thesis is furthermore limited to vehicle-to-vehicle communication relying, thereby assuming infrastructure-less vehicular networks. This is reasonable due to the fact that in highway and in the early deployment stage of urban scenarios, message dissemination solutions work in the absence of any infrastructure support. Therefore, the overall objectives of the thesis are as follows.

1. To analyze the existing solutions of message propagation in vehicular networks with respect to both safety and service-oriented messages.

2. To propose a robust message dissemination protocol to transmit safety-oriented data in a timely manner to all vehicles within the intended geographic region, while minimizing the number of transmissions.

3. For the case of service related applications, our objective is to design an efficient routing protocol that transfers service oriented messages between source and destination pairs with promising data delivery by minimizing the overall delivery delay.

4. For the above proposed protocols to work reliably and efficiently, this thesis extends its objective towards a cooperative network environment through a cluster-based payment and punishment mechanism. The main intention is to motivate the vehicles to participate selflessly and cooperatively during network operations, especially in the course of message dissemination.

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