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Review on Recent Techniques for Reducing Packet Drops in Dense and Sparse Vehicular Network Scenarios

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Abstract: Vehicular networks have been the trending topic of research since the past decade that can be attributed to its enormous potential to enhance road safety, traffic efficiency and furnish un-interrupted service to the users over the course of mobility. Vehicular communications are being perceived as an enabler for driverless cars of the future. Automobile industries, governments and research community across the globe are investing extensive effort and capital towards the deployment of vehicular networks owing to the gigantic potential envisaged in its applications. Vehicular networks represent a special sub-class of MANET that presents numerous research challenges due to their distinct features such as hybrid network architectures, node movement characteristics and new application scenarios. Designing efficient routing protocols for VANET remains one of the most prominent challenging issues. The major challenge associated with Delay Tolerant Networks (DTN) protocols is ensuring fewer packet drops while ignoring delay. This paper reviews the works that lessen packet drops by exploiting position, social and velocity information of nodes in dense and sparse vehicular networks.

Keywords: VANET, Routing, RSU, QoS, MSN, MANET, DSR

I.INTRODUCTION

Vehicular Ad-hoc Networks (VANETs) are realized by applying the standards of Mobile Ad-hoc Networks (MANETs) – the unconstrained formation of a wireless network for information trade – to the domain of vehicles. VANETs were first specified and presented in 2001 under "car-to-car ad hoc mobile communication and networking" applications, where networks can be framed and data can be handed-off among cars. VANETs are an essential component of modern Intelligent Transportation Systems (ITS). VANETs represent a special sub-class of MANET that is realized by integration of Wireless LAN (WLAN), ad-hoc network and cellular technology to achieve intelligent Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications. Vehicles in VANET context are assumed to be equipped with a set of wireless sensors and On-Board Units (OBUs) to facilitate communication between vehicles and their environments. RSUs are situated at strategic positions on the roads to ensure effective, reliable and timely vehicular communications. Vehicular communication configurations are highly dependent on the acquisition of up-to-date and accurate kinematic data of both vehicles as well as surroundings with the aid of positioning systems and intelligent wireless communication protocols. The major motivation behind extensive research being carried out at present in the area of vehicular networks is the vast potential envisaged in its applications. Government agencies, the research community and automobile industries across the globe are investing extensive effort and capital in the deployment of vehicular networks on a large scale. V2V communication provides the advantages of lower deployment costs, allowing short and medium range communications and minimizing latency in the communication link. On the other hand, V2I communications provide the advantages of information dissemination particularly using advanced antennas and covering a broader/wider range than that achieved through V2V communications. Vehicular Networks (VANETs) offer both safeties as well as non-safety applications. Safety applications are aimed at enhancing road safety, reduction of accidents while non-safety applications are aimed at traffic management & control, offering entertainment, updates, and comfort to the passengers. Routing remains a prominent challenging issue and designing efficient routing algorithms for vehicular networks remains a herculean task. Most of the routing solutions proposed in literature resolve one issue while raising another. While some routing solutions are concerned with minimizing the delivery delay from source to destination, others aim to maximize delivery ratios at the expense of high delay. Since vehicular networks usually suffer the issue of intermittent connectivity or highly variable link performance and no complete path exist from source to destination for the majority of the times, the challenge of achieving high throughput/reducing packet drops surfaces.

Another issue is the variable traffic density, i.e. dense and sparse nature of vehicular networks that make it difficult to design routing solutions that ensure efficient performance in terms of throughput. DTN protocols serve as a promising solution for networks in which achieving high throughput/delivery rates remain the major concern at the cost of high end-to-end delay. Over the years, several routing solutions have been proposed in the literature for ensuring high throughput/delivery rates for both dense as well as sparse vehicular scenarios. Social, position and velocity information of nodes has been exploited extensively in some of the recent solutions that aim to increase delivery rates/reduce packet drops. These serve as promising solutions for ensuring high throughput despite the frequent fragmentation issues in vehicular networks.

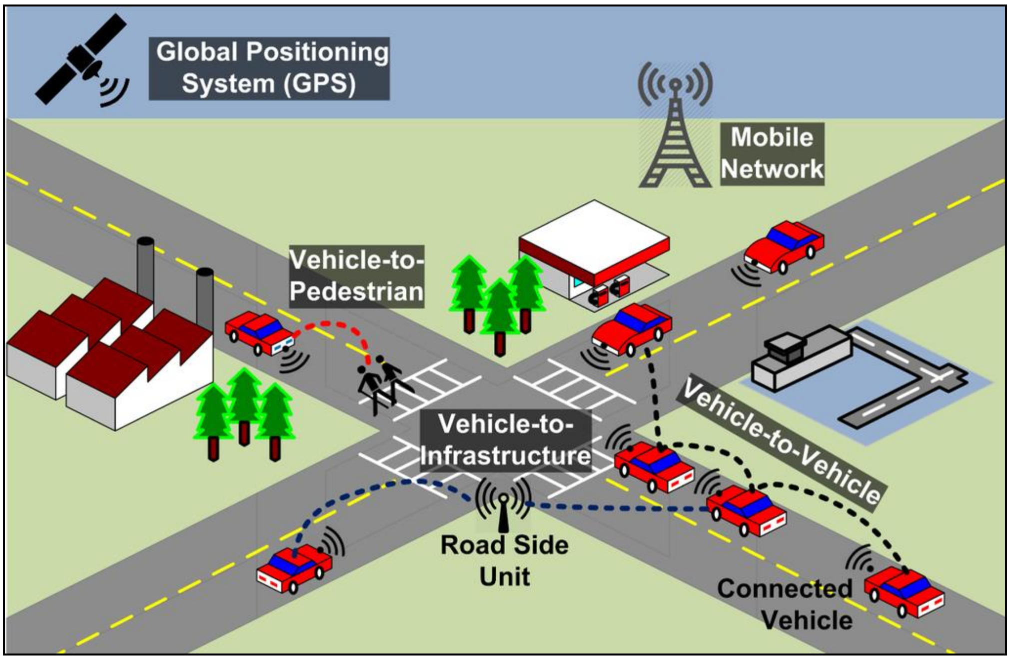

Figure 1 depicts the Architecture of Vehicular Networks

II. CHARACTERISTICS OF VANET

Vehicular networks possess some distinct characteristics that make it different from MANET as well as challenging for designing VANET applications.

High Dynamic Topology: Vehicular networks possess highly dynamic topology due to the movement of vehicles at variable speeds.

The frequent Disconnected Network: Highly dynamic topology of VANET results in frequent network disconnections or intermittent connectivity. The disconnections occur mostly in sparse networks.

Mobility Modeling: The mobility of vehicles in vehicular networks is constrained by traffic environment, road layout & design, the speed of vehicles, driver's driving behaviour and so on.

Unlimited Battery Power and Storage Capacity: Battery power and storage are not constraints for modern vehicles and are available in ample amount. Therefore, vehicular networks have ample computing power which is unavailable in MANET. This feature ensures effective communication.

Different Communication Environments: Vehicular networks can be deployed in different environments. The environments commonly used to deploy vehicular networks include the highway, urban/city, and rural environments. In the highway scenarios, the environment is assumed to be free-space, however, the signal can suffer interference by reflection with the wall panels around the roads. In city scenarios, the environment is complex due to variable vehicle density and the presence of buildings, trees and other objects serving as obstacles to signal propagation and leading to shadowing multipath and fading effects. In the rural scenarios, the communication environment is complex due to the presence of complex topographic forms such as dense forests, hills, fields, climbs, etc. that lead to signal attenuation and signal reflection.

Interaction with Onboard Sensors: Vehicles in VANET context are assumed to be equipped with onboard sensors that supply information that serves useful for forming communication links.

Non-Homogeneous Node Distribution Pattern: Node distribution pattern in vehicular scenarios is non-homogenous along the road segment because of varying speeds of vehicles, traffic lights, the presence of obstacles, driving patterns, etc.

Geographical Communication: In comparison to the other networks that utilize unicast or multicast, i.e. where the target vehicle or group of target vehicles are defined by an ID or a group ID, VANETs define a new type of communication where vehicles to be reached typically depend on their geographical position/location.

III. RESEARCH ISSUES IN VANET

Vehicular networks are distinct from other ad-hoc networks in several aspects which bring forward several prominent research challenges. Numerous issues need to be resolved while deploying a vehicular network usually from distant fields of expertise ranging from applications development up to economic issues.

Some of the prominent research challenges are as follows:

Efficient Routing Protocol Design: Designing efficient routing protocols for vehicular networks is vital to route the packets while ensuring minimum end-to-end delay and minimum packet drops. Vehicles in VANET scenario travel at variable speeds. Dynamic topology of VANET leads to frequent network disconnections or intermittent connectivity. Though the extensive study has been already carried out and research community has proposed several routing protocols over the years, designing efficient routing protocols for VANET that ensure minimum packet drops and minimum end-to-end delay still remains a significant challenging issue.

Bootstrap: At present, only limited vehicles are equipped with wireless technology and also roadside units (RSU) may not be deployed at every location. Therefore, only limited number of vehicles will be able to participate in vehicular communications even if efforts are made to formulate communication. Hence, deploying vehicular networks on a large scale requires substantial investment from top commercial firms and governments across the globe.

Power Adjustment and Control: Power management in terms of Transmission Power (TX) is a major research issue that needs to be resolved in order to ensure effective vehicular communications. In dense vehicular networks, high transmission power can disrupt an ongoing transmission with another transmission at a distant vehicle due to interferences. The major issue is an adjustment of transmission power while also ensuring efficient routing, i.e. increase in overall throughput and reduction in interference occurrences.

Security and Privacy: Security and Privacy are factors that must be guaranteed by vehicular networks to win credibility from users, otherwise, compromise on these factors will lead to low acceptance of vehicular networks by the community. Designing efficient protocols guaranteeing security is essential to prevent fake or fraudulent messages from being transmitted into the network that can lead to disruption of traffic flows or even danger. Further, privacy must be preserved, i.e. vehicular communications should not make vehicle tracking or identification possible for non-trusted parties. Hence, designing efficient protocols guaranteeing security and privacy is an important research issue in VANET.

The quality of Service (QoS): Guaranteeing certain Quality of Service (QoS) levels is vital for users' satisfaction. Certain Quality of Service (QoS) levels can be guaranteed by a network having characteristics such as minimum delay for data delivery, fewer retransmissions, and high connectivity. Guaranteeing certain levels of QoS with different user applications and dynamic network environment represents an important research issue in VANET.

IV.LITERATURE REVIEW

Wei Yan et al. (2010), This paper examines the distinct characteristics of urban VANETs such as vehicles have different types and move in the form of clusters due to the impact of traffic lights. This paper utilizes the concept of using buses as the mobile infrastructure to enhance network connectivity. The approach relies on increasing the transmission range of buses in order to achieve improvements in network connectivity. The paper proposes a novel routing technique called MIBR (Mobile Infrastructure Based Protocol) which is a location based reactive routing protocol that considers buses and cars as the vehicles in urban VANET scenarios and assumes that each vehicle has a digital street map including bus line information. The proposed protocol operates in two phases. The first step involves selection of an optimal route that comprises a sequence of road segments with the best-estimated transmission quality. The second phase involves forwarding packets using multi-hop with efficiency through each segment in the selected route. The authors have simulated the proposed approach using NS-2 and compared it to GPSR in terms of delivery ratio and throughput. Simulation results reveal that the proposed approach achieves substantial performance enhancement in terms of delivery ratio & throughput, has low complexity and is economical to deploy. [1]

Michael Slavik et al. (2012), In this paper, a Distribution-Adaptive Distance with Channel Quality (DADCQ) protocol has been proposed to address broadcast communications in vehicular networks. The proposed approach uses the distance method for the selection of forwarding nodes. The performance of the proposed technique relies heavily on the value of the decision threshold, however, selection of a value that leads to good performance across all scenarios is difficult. The optimal value is affected by factors such as spatial distribution pattern, node density, and wireless channel quality. The proposed work addresses this challenge by creating a decision threshold function that adapts simultaneously to factors such as a number of neighbours, node clustering factor, and Rician fading parameter. Quadrat method of spatial analysis is utilized to compute the clustering factor. The proposed approach is simulated with JiST/SWANS and VanetMobiSim in urban and highway traffic scenarios. The performance of the proposed approach is examined with respect to parameters such as the effect of fading intensity and effect of node density. Simulation results reveal that the proposed approach provides high reachability and efficiently utilizes bandwidth in both urban and highway scenarios. [2]

Rameswar Panda et al. (2012), This paper raises the subject that clustering is one technique by means of which vehicular networks can be made scalable. This paper proposes a novel approach to create clusters by taking into consideration direction, position and relative speed of the vehicle for managing the issue of scalability. A novel approach has been proposed for selection of the most suitable cluster-head (CH) by taking into consideration the real-time updated position and trust value of vehicles. Ant colony optimization based on trust for the simple highway scenario VANET has been used in this work. The proposed work was simulated and the authors conclude that the proposed algorithm has outperformed the standard AODV and Mobility-aware Ant Colony Optimization Routing (MAR-DYMO) approaches in terms of routing overhead. [3]

Vikram Kumar et al. (2013), In this paper, a protocol for routing in MANET is proposed that utilizes Dynamic Source Routing (DSR). The proposed protocol quickly adapts to changes in routing path as the host changes its position frequently. The proposed mechanism consists of two operations that include route discovery and route maintenance that work in conjunction to search for the shortest path. DSR protocol is optimized using ANT algorithm in order to maintain source routes to arbitrary destinations in MANET. The performance of the proposed algorithm is evaluated using QualNet 5.2 using parameters such as end-to-end delay, throughput, routing overhead and average hop count. All the parameters are examined in three different scenarios of traffic connection, velocity and pause time. The authors conclude that the proposed algorithm outperforms the standard DSR protocol with respect to all the examined parameters. [4]

Mingjun Xiao et al. (2014), This paper proposes a Community-Aware Opportunistic Routing (CAOR) algorithm for mobile social networks. A home-aware community model is proposed in the paper wherein an MSN (Mobile Social Network) is turned into a network that includes only community homes. The authors use a reverse Dijkstra algorithm to compute the minimum expected a delivery delay of nodes in the network of community homes and attain the optimal opportunistic routing performance. The computational cost and maintenance cost of contact information is substantially reduced since the number of communities is far less than the number of nodes in magnitude. The authors simulate the proposed algorithm using the MSN trace and examine the performance of the algorithm on the basis of metrics such as delivery delay, delivery hops, and delivery ratio. The authors conclude that the proposed algorithm substantially outperforms the existing approaches and can significantly enhance MSN routing performance. [5]

Lin Bai et al. (2014), This paper examines that a highly detailed community structure can provide its contribution to a better understanding of the network that can also prove beneficial in the design of efficient routing protocols and QoS schemes. The paper further describes that in an opportunistic network having a different type of mobile nodes, the topology varies over time and hence, community detection becomes a more challenging task in such networks. A novel detection algorithm is proposed to solve the overlapping community detection problems in opportunistic networks. The proposed algorithm allows the nodes to get their overlapping community structures only with the local network topology information and a short period. The authors have performed the simulations on the ONE simulator and conclude that the proposed scheme has high reliability and flexibility for overlapping community detection in dynamic topology based opportunistic networks. [6]

Juan Luo et al. (2015), This paper deals with the energy savings optimization aspect of wireless sensor networks since the majority of sensor nodes are equipped with limited non-rechargeable battery power. The paper focuses on minimizing energy consumption and maximizing network lifetime for data relay in one-dimensional queue network. The paper proposes an Energy Saving via Opportunistic Routing (ENS_OR) algorithm to ensure minimum power cost during data relay and offers protection to nodes with relatively low residual energy. The algorithm makes multi-hop relay decision with a view to optimizing the network energy efficiency on the basis of differences among the sensor nodes in aspects such as their distance to the sink node and residual energy of each other. The authors simulate the proposed algorithm using MATLAB and conclude that the proposed approach substantially enhances the network performance in terms of energy savings and wireless connectivity. [7]

Gary K.W. Wong et al. (2015), This paper proposes Social Relation Opportunistic Routing (SROR) algorithm for mobile social networks. This algorithm utilizes social relations and profiles among nodes as the main metrics to compute the optimal forwarding node in routing with a view to maximizing the packet delivery probability. The proposed algorithm executes three consecutive subroutines through a distributed algorithm with the objective to compute the best forwarding candidate. The performance of the algorithm is assessed on parameters such as packet delivery probability and algorithm efficiency metrics. Simulation results reveal that the proposed approach outperforms the existing techniques and that social-based routing approaches prove beneficial and practical for dynamic social networks with a wide range of applications. It can also be inferred that social-based approaches prove more promising in comparison to conventional opportunistic routing protocols as social properties offer more stability over the unstable dynamic characteristics in the environment such as mobility pattern and network topology. [8]

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