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Enabling Secure Transportation System using VANET

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ABSTRACT: The proposed approach aims to identify "critical" road segments and to prevent a traffic jam before it actually occurs. Therefore, we will show that, for the estimation of traffic flow dynamics, a purely density-based analysis does not suffice. Consequently, it is necessary to understand the nature of traffic breakdown, which describes a spontaneous drop of the average velocity on a stretch of road; often, a breakdown spontaneously occurs without an obvious cause such as a construction site or an accident. It is actually caused by misbehavior of human drivers in dense traffic. Therefore, we suggest using periodically emitted beacons to analyze the current traffic state. Communicating vehicles change their driving behavior in dense traffic and inform following vehicles about the discovery of dense traffic. After a vehicle has changed its driving behavior, it is expected to be less likely the trigger of traffic breakdown. This makes our method different from many previous approaches that guide vehicles to less-congested routes to escape congestion.

KEYWORDS: Ad-hoc network, MANET, IVC

I. INTRODUCTION

1.1 Objective of the project

This project addresses the question of how vehicular communication can be applied to make transportation more efficient. This approach is based on two points: Vehicles autonomously estimate the current traffic situation and broadcast this information, and based on this estimate and if required by the traffic state, vehicles adapt their driving behavior. We admit that the first point, VANET-based traffic state estimation, has already been investigated earlier. The focus of the previous studies, however, was on the detection of congestion or of large vehicle densities with respect to dynamic route choice or radio channel analysis. Our approach aims to identify "critical" road segments and to prevent a traffic jam before it actually occurs. Therefore, we will show that, for the estimation of traffic flow dynamics, a purely density-based analysis does not suffice. Consequently, it is necessary to understand the nature of traffic breakdown, which describes a spontaneous drop of the average velocity on a stretch of road; often, a breakdown spontaneously occurs without an obvious cause such as a construction site or an accident. It is actually caused by misbehavior of human drivers in dense traffic. Therefore, it suggests using periodically emitted beacons to analyze the current traffic state. Communicating vehicles change their driving behavior in dense traffic and inform following vehicles about the discovery of dense traffic. After a vehicle has changed its driving behavior, it is expected to be less likely the trigger of traffic breakdown. This makes our method different from many previous approaches that guide vehicles to less-congested routes to escape congestion.

Periodic beacons that we use for message exchange are essential for most safety applications and have therefore been extensively studied. Hence, this paper will focus on the aspects related to traffic dynamics; although it has to admit that more innovative beacon schemes are the object of current research.
Due to the infeasibility of large-scale real-world experiments, computer simulations have become a valuable instrument in this field of research. To assess the impact of the proposed strategy, it uses computer simulations with both very realistic propagation and traffic models. In addition to that, we use empirical traffic data from a German Autobahn

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where a traffic breakdown was observed. The necessary penetration rate for the proposed strategy to become effective will be also in the focus of this project.

1.2 About the project

A mobile ad-hoc network (MANET) is a self-configuring infrastructure less network of mobile devices connected by wireless. Ad hoc is Latin and means "for this purpose".

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet.

MANETs are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a Link Layer ad hoc network.

The growth of laptops and 802.11/Wi-Fi wireless networking has made MANETs a popular research topic since the mid-1990s. Many academic papers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measure such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput etc.

Types of MANET

Vehicular Ad-hoc Networks (VANETs) are used for communication among vehicles and between vehicles and roadside equipment.

Internet Based Mobile Ad-hoc Networks (iMANET) are ad-hoc networks that link mobile nodes and fixed Internet-gateway nodes. In such type of networks normal ad hoc routing algorithms don't apply directly.

Security of MANETS

A lot of research was done in the past but the most significant contributions were the PGP (Pretty Good Privacy) and the trust based security but none of the protocols made a decent tradeoff between security and performance. In an attempt to enhance security in MANETs many researchers have suggested and implemented new improvements to the protocols and some of them have suggested new protocols.

Classification of attacks in MANET

These attacks on MANETs challenge the mobile infrastructure in which nodes can join and leave easily with dynamics requests without a static path of routing. Schematics of various attacks as described by on individual layer are as under:[1]

- Application Layer: Malicious code, Repudiation
- Transport Layer: Session hijacking, Flooding
- Network Layer: Sybil, Flooding, Black Hole, Grey Hole. Worm Hole, Link Spoofing, Link Withholding, Location disclosure etc.
- Data Link/MAC: Malicious Behavior, Selfish Behavior, Active, Passive, Internal External
- Physical: Interference, Traffic Jamming, Eavesdropping

VANET

A **Vehicular Ad-Hoc Network** or **VANET** is a technology that uses moving cars as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 meters of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created. It is estimated that the first systems that will integrate this technology are police and fire vehicles to communicate with each other for safety purposes.

Applications

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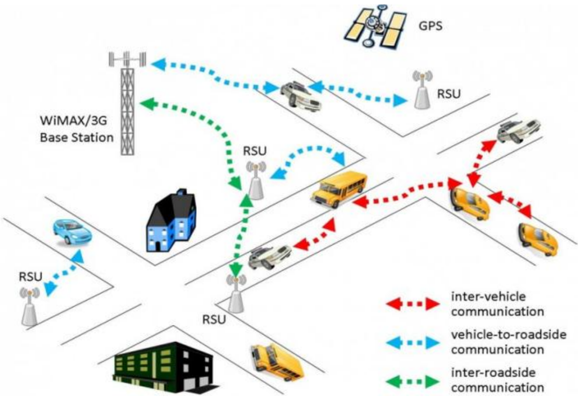
Most of the concerns of interest to MANets are of interest in VANets, but the details differ. Rather than moving at random, vehicles tend to move in an organized fashion. The interactions with roadside equipment can likewise be characterized fairly accurately. And finally, most vehicles are restricted in their range of motion, for example by being constrained to follow a paved highway.
In addition, in the year 2006 the term MANet mostly describes an academic area of research, and the term VANet perhaps its most promising area of application. VANET offers several benefits to organizations of any size. While such a network does pose certain safety concerns (for example, one cannot safely type an email while driving), this does not limit VANET's potential as a productivity tool. GPS and navigation systems can benefit, as they can be integrated with traffic reports to provide the fastest route to work.



VANET

A computer can turn a traffic jam into a productive work time by having his email downloaded and read to him by the on-board computer, or if traffic slows to a halt, read it himself. It would also allow for free, VoIP services such as GoogleTalk or Skype between employees, lowering telecommunications costs. Future applications could involve cruise control making automatic adjustments to maintain safe distances between vehicles or alerting the driver of emergency vehicles in the area.
To support message differentiation in VANET, IEEE 802.11e standard is incorporated in vehicular communication.

Technology
In VANET, or Intelligent Vehicular Ad-Hoc Networking, defines an Intelligent way of using Vehicular Networking. In VANET integrates on multiple ad-hoc networking technologies such as WiFi IEEE 802.11p, WAVE IEEE 1609, WiMAX IEEE 802.16, Bluetooth, IRA, ZigBee for easy, accurate, effective and simple communication between vehicles on dynamic mobility. Effective measures such as media communication between vehicles can be enabled as well as methods to track the automotive vehicles.[3]
In VANET helps in defining safety measures in vehicles, streaming communication between vehicles, infotainment and telematics.
Vehicular Ad-hoc Networks are expected to implement a variety of wireless technologies such as Dedicated Short Range Communications (DSRC) which is a type of WiFi. Other candidate wireless technologies are Cellular, Satellite, and WiMAX. Vehicular Ad-hoc Networks can be viewed as component of the Intelligent Transportation Systems (ITS).[4]
As envisioned in ITS, vehicles communicate with each other via Inter-Vehicle Communication (IVC) as well as with roadside base stations via Roadside-to-Vehicle Communication (RVC). The optimal goal is that vehicular networks will contribute to safer and more efficient roads in the future by providing timely information to drivers and concerned authorities.[2]

1.3 Purpose of the project
Broadcasting in vehicular ad hoc networks (VANET) isemerging as a critical area of research. One of the challenges posed by this problem is the confinement of the routing problem to vehicle-to-vehicle (V2V) scenarios as opposed to

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also utilizing the wireless infrastructure (such as cellular networks). At a fundamental level, safety and transport efficiency is a mandate for current car manufacturers and this has to be provided by the cars on the road as opposed to also using the existing wireless communications infrastructure.

This project report the first comprehensive study on the subject whereby the extreme traffic situations such as dense traffic density, sparse traffic density, and low market penetration of cars using DSRC technology are specifically taken into account. We show that our Distributed Vehicular Broadcasting protocol can cope with all of these important considerations.

1.4 Scope of the project

To the best of our knowledge, however, there is no prior study that can handle both the disconnected network and broadcast storm problems in a seamless manner via a distributed routing protocol for highway VANET scenarios. Our work fills this gap by designing a fully distributed new VANET broadcast protocol known as DV-CAST. Unlike existing studies, the proposed DV-CAST protocol can suppress the broadcast storm in a dense VANET environment in addition to routing in a sparsely connected VANET. The algorithm relies only on GPS information of the one-hop neighbors and does not require any centralized node or maps. The motivation for using the local topology information in our framework is to minimize the additional network overhead and keep the complexity of the protocol to a minimum.

1. Inter-Vehicle Communications: Achieving Safety in a Distributed Wireless Environment

Vehicular 'active safety' can be enhanced by the wireless exchange of information among the vehicles driving along a road. In particular, inter-vehicle communications (IVC) can support safety systems designed to avoid road accidents by two means. First, periodic transmissions from all vehicles to inform their neighbors about their current status enable accident prevention by being capable of identifying dangerous road situations. Second, the fast dissemination of emergency information whenever a hazard has been detected can help drivers avoid the danger. The goal of this thesis is to design required communication protocols and systems in order to provide the means for a robust and effective transmission of safety-related information. This literature proposes two methods based on power control and contention mechanisms to shape data traffic such that messages are received with high probability where they are relevant. First, we propose a method based on a strict fairness criterion, D-FPAV, to control the load of periodic messages on the channel while ensuring a high probability of message reception within the safety distance of the sending vehicle. Second, we propose a method, EMDV, for fast and effective dissemination of emergency messages within a geographical area.[8]

Advantages:

- Periodic transmissions from all vehicles to inform their neighbors about their current status enable accident prevention by being capable of identifying dangerous road situations.
- The fast dissemination of emergency information whenever a hazard has been detected can help drivers avoid the danger.[5]

Drawback:

- Assuming that all nodes are placed on a straight line, the spatial location where a hidden node can be found corresponds to the range limited by the borders of the transmitter and the receiver carrier sense ranges, which we call HN range.

II. SECURE AND EFFICIENT BEACONING FOR VEHICULAR NETWORKS

The basis for many VANET applications is periodic beacons carrying information like location, heading and speed. In order to secure beaconing, messages should be signed and carry a certificate to attest valid network participants. In order to reduce the significant communication and computational overhead created by this, we propose to skip signatures or certificates in certain situations. When verifying the validity of a certificate, this corresponds to one signature verification. By storing already verified certificates locally, subsequent beacons containing the same

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certificate can be verified without cryptographic operation. This already cuts the computational costs of handling received packets almost by half, yet to the cost of some more memory.

In order to show the effectiveness of our approaches, we conducted extensive simulations that show the savings in terms of communication and/or computational overhead and also the rate of unverifiable packets. Whereas full details of this evaluation will be given in future work, we want to highlight some of our results shown. For this simulation, we have implemented certificate omission based on neighbor changes. It depending on traffic model (city or highway traffic), traffic density, and beacon intervals, the number of beacons with certificates is significantly reduced. With small beacon intervals, which are often recommended for faster reaction times of eSafety applications, more than 80% of certificates can be omitted, resulting in large bandwidth saving. At the same time, analysis of simulation results shows that the number of beacons that are not instantly verifiable due to unknown certificates is in the order of 1%.[6]

Advantages

- This will increase reliability of safety applications and the deployment rate of eSafety systems while still providing systems that are hard to attack.

Disadvantages

- It cannot reduce the significant communication and computational overhead.

3. Statistical physics of vehicular traffic and some related systems

In the so-called `microscopic' models of vehicular traffic, attention is paid explicitly to each individual vehicle each of which is represented by a `particle'; the nature of the `interactions' among these particles is determined by the way the vehicles influence each others' movement. Therefore, vehicular traffic, modeled as a system of *interacting* `particles' *driven far from equilibrium*, offers the possibility to study various fundamental aspects of truly non equilibrium systems which are of current interest in statistical physics. Analytical as well as numerical techniques of statistical physics are being used to study these models to understand rich variety of physical phenomena exhibited by vehicular traffic. Some of these phenomena, observed in vehicular traffic under different circumstances, include transitions from one dynamical phase to another, criticality and self-organized criticality, Meta stability and hysteresis, phase-segregation, etc. In this critical review, written from the *perspective of statistical physics*, we explain the guiding principles behind all the main theoretical approaches. But we present detailed discussions on the results obtained mainly from the so-called `particle-hopping a models, particularly emphasizing those which have been formulated in recent years using the language of cellular automata.[7]

Looking at recent standardization efforts and fields tests it becomes clear that beaconing will initially be a cornerstone for upcoming C2X eSafety applications. With beaconing we denote the periodic transmission of packets containing a vehicle's position and other information as a (single-hop) link-layer broadcast to all neighboring vehicles or roadside units. Implemented in an insecure way, beaconing opens opportunities for abuse. To address these problems, many security solutions suggest using signatures based on asymmetric cryptographic mechanisms like ECDSA together with more mechanisms. The basic strategy is to equip vehicles with asymmetric cryptographic key pairs (VK, SK) and certificates (Cert) issued by a trusted certification authority (CA). Then all beacons get signed using the vehicle's signature key SK and receivers verify them using the verification key VK. Signature and certificate containing VK are attached to the beacon.

The concepts and techniques of statistical physics are being used nowadays to study several aspects of complex systems many of which, till a few decades ago, used to fall outside the traditional domain of physical systems. Physical-, chemical-, earth-, biological- and social-sciences as well as technology meet at this frontier area of inter-disciplinary research. Flow of vehicular traffic and granular matter, folding of proteins, formation and growth of bacterial colonies, biological evolution of species and transactions in "nancial markets are just a few examples of exotic phenomena in such systems. Most of these systems are interesting not only from the point of view of Natural Sciences for fundamental understanding of how Nature works but also from the points of view of applied sciences and engineering for the potential practical use of the results of the investigations. Our review of the current status and future trends of research on the theory of vehicular traffic (and some related systems) will, we hope, convince you that,

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indeed, the results of recent studies of complex systems have been `a conceptual revolution, a paradigm shift that has far reaching consequences for the very definition of physics.

Advantages

- In this literature, some of these phenomena, observed in vehicular traffic under different circumstances, include transitions from one dynamical phase to another, criticality and self-organized criticality, meta stability and hysteresis, phase-segregation, etc.

Disadvantages

- The nature of the congested traffic is still under debate.

4. Common Traffic Congestion Features studied in USA, UK, and Germany employing Kerner's Three-Phase Traffic Theory

Based on a study of real traffic data measured on American, UK and German freeways common features of traffic congestion relevant for many transportation engineering applications are revealed by the application of Kerner's three-phase traffic theory. General features of traffic congestion, i.e., features of traffic breakdown and of the further development of congested regions, are shown on freeways in the USA and UK beyond the previously known German examples. A general proof of the theory's statements and its parameters for international freeways is of high relevance for all applications related to traffic congestion. The application ASDA/FOTO based on Kerner's three-phase traffic theory demonstrates its capability to properly process raw traffic data in different countries and environments.

In many countries of the world, traffic on freeways is often heavily congested during many hours of the day. Common traffic congestion features, especially features of traffic breakdown as well as features of propagating "jam" structures, have to be taken into account in diverse applications, e.g., adaptive cruise control systems, traffic safety applications, V2V / V2I (Vehicle-to-Vehicle / Vehicle-to-Infrastructure) technologies for individual vehicles as well as traffic control and management systems for collective traffic management centres.

In recent years the so-called three-phase traffic theory has been proposed by Kerner (2004, 2009b): in addition to free flow traffic phase (F), the lower speed states of congested traffic on freeways have to be distinguished between the two traffic phases: synchronized flow (S) and wide moving jam (J). While the synchronized flow regions remain often fixed at the location of the bottleneck and the wide moving jam propagates through any kind of a bottleneck, both congested traffic phases might have similar vehicle speeds, e.g., measured by local detectors. Hence, only a spatial-temporal investigation of a congested traffic state allows the consistent congested traffic phase classification.

Advantages

- Flow-density method is valid for the investigation of other parameters of wide moving jams, but the traffic data has to be analyzed more carefully taking possible inflows and outflows at ramps into account.

Disadvantages

- Only a spatial-temporal investigation of a congested traffic state allows the consistent congested traffic phase classification.[10]

5. A cellular automation model for freeway traffic

In recent times, the methods of nonlinear dynamics were successfully applied to these models, stressing the notion of a phase transition from laminar flow to start-stop-waves with increasing car density. Automatic detection of stronger fluctuations near this critical point has already been used to install better traffic control systems. This literature introduces a stochastic discrete automaton model to simulate freeway traffic. Monte-Carlo simulations of the model show a transition from laminar traffic flow to start-stop-waves with increasing vehicle density, as is observed in real freeway traffic. For special cases analytical results can be obtained.

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MERITS

- This project shows a transition from laminar traffic flow to start-stop-waves with increasing vehicle density, as is observed in real freeway traffic.[9]

DRAWBACKS

- It cannot investigate multi-lane traffic.

III. EXPERIMENTAL METHODS

More innovative approaches search to influence the driving behavior that causes the breakdown. Kerneret al. suggested that the exchanged messages should comprise the length of a recommended space gap that vehicles are to maintain. Vehicles that adapt their space gap according to the recommendation are less likely to provoke a traffic breakdown. Similarly, Feketeet al. proposed that vehicles adapt their own velocity to the average velocity of neighboring vehicles, which they determine via inter vehicle communication, thus reducing in homogeneities in traffic flow. The previous two works studied the influence of their strategies for relatively high penetration rates of communicating vehicles of 100% and 60%, respectively.[11]

Such rates will be reached only long after a successful market introduction of VANET devices. Moreover, it is not clear when, if at all, vehicles are to alter driving behavior. Recently, Knorr and Schreckenberg have found beneficial impact of VANETs on traffic flow for penetration rates considerably below 50%. They gave both recommendations for when and how to change driving behavior. Their simulation, however, were based on some idealized traffic and communication conditions and did not take into account the human limitations, namely reaction time, in adapting driving behavior.

3.1.2 Proposed System

This project presents a VANET-based strategy to reduce traffic jams, which explicitly accounts for human reaction time and becomes effective at low penetration rates. Simulations not only use realistic radio propagation and mobility models but also empirical traffic data from a German Autobahn, which makes this project stand out from existing system. Our approach to use vehicle-to-vehicle communication to ease congestion is solely based on beacon messages. Beacon messages are periodically broadcast status messages containing a vehicle's position, velocity, acceleration, a unique vehicle identifier, and a time stamp. This information suffices to estimate the local state of traffic. In our approach, we suggest expanding a beacon's content by two additional variables: a position *cs*and a time stamp *ct* marking a "critical" road segment. In this context, we will call a road segment critical when a breakdown is likely to occur. By employing the data that are already sent in regular beacons and merely extending it with two piggybacked data fields, we do not create overhead due to additional packets in the network. A beacon's payload size is estimated to be less than 100 B, depending on the lengths of headers and other data not directly related to our approach; however, to pay attention to expected future demands, e.g., security, we fix the beacon size to 500 B in our following considerations to demonstrate that our approach is able to work with those beacon sizes.

3.4 Module Description

3.4.1 Network Design

VANET is very different from routing in mobile ad hoc networks (MANET) due to several reasons such as network topology, mobility patterns, demographics, traffic patterns at different times of the day, etc. VANETs enable all actors in traffic to exchange information and to coordinate their behavior.

3.4.2 Beacon message generation

Beacon messages are periodically broadcast status messages containing a vehicle's position, velocity, acceleration, a unique vehicle identifier, and a time stamp. This information suffices to estimate the local state of traffic. In our

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approach, we suggest expanding a beacon's content by two additional variables: a position and a time stamp marking a "critical" road segment.

3.4.3 V2V transmission

The proposed system to use vehicle-to-vehicle communication to ease congestion is solely based on beacon messages. From the beacons that a vehicle receives during an interval, it may calculate the average velocity of all transmitting vehicles ahead. Vehicles use this information to decide whether to change their driving behavior. For this decision, a vehicle has to judge the relevance of the information.

3.4.4 V2B transmission

Global topology information may be collected by this infrastructure using Road Side Units (RSU). Vehicles send beacon message to nearest Road Side Unit. Then this road side unit will sends this message to base station.

IV. FUTURE ENHANCEMENTS

Once the system has been designed, the next step is to convert the designed one in to actual code, so as to satisfy the user requirements as excepted. If the system is approved to be error free it can be implemented.

When the initial design was done for the system, the department was consulted for acceptance of the design so that further proceedings of the system development can be carried on. After the development of the system, a demonstration was given to them about working of the system. Implementation includes proper training to end-users. The implemented software should be maintained for prolonged running of the software.
Initially the system was run parallel with manual system. The system has been tested with data and has proved to be error-free and user-friendly. Training was given to end -user about the software and its features.

V. CONCLUSION

This project has proposed a new Distributed Vehicular Broadcasting protocol (DV-CAST) design for safety and transport efficiency applications in VANET. The designed protocol addresses how to deal with extreme situations such as dense traffic conditions during rush hours, sparse traffic during certain hours of the day (e.g., midnight to 4 am in the morning), and low market penetration rate of cars using DSRC technology. The proposed DV-CAST protocol is fully distributed and relies on the local information provided by one-hop neighbors via periodic hello messages.

For future work, it would be interesting to see how much of the underlying design principles of DV-CAST would also be applicable to urban areas. Further we are going to concentrate how to overcome DDOS attack.

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