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PART I : IoV communications and networking

Network Architectures in Internet of Vehicles (IoV): Review, Protocols Analysis, Challenges and Issues ?

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Abstract. Since some decades ago, the evolution of the Internet continues to revolutionize many aspects of human life. It started by connecting computers, then smartphones before it becomes generalized to connecting everything that gives birth to the Internet of Things (IoT) paradigm. Thanks to the telecommunication and technologies' advancements, vehicles are now able to have internet access and communications capabilities, thus, making communications networks called Vehicular Ad hoc Networks (VANETs). The Internet of Vehicles is, therefore, an evolution of VANETs where IoT is applied and in which the main component is the vehicle. Besides the many opportunities that IoV presents, there are still many challenges and issues that must be considered with great attention such as efficient and reliable network architectures that should provide an efficient IoV deployment. This is why, in this paper, we have made our contribution by establishing a review of existing novel IoV architecture solutions and we further propose a protocol stack analysis of these architectures.

Keywords: IOV, VANET, D2D, Network Architectures, C-ITS

Improved Latency of CAN Vehicle Data Extraction Method

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Abstract. Road vehicle-related data can be classified into multiple types. The technical data generated through the controller area network (CAN) bus technology provide real-time information on the vehicle. This is one of the important data that can support vast range of services for various applications like in intelligent transportation systems. OBD system is a widespread solution for extracting these data from the vehicles. Unfortunately, most of the past re-searches don't consider the accuracy and reliability of their input data extracted from OBD. Most of the current systems for vehicle data extraction are based on the integration of microcontroller boards and smartphones. These systems do not have a high modularity and flexibility, due to their limitations in terms of both hardware and software. This study aims to present a real-time system for communicating with the CAN bus, which could work as the system server-side for improving vehicle data extraction with higher data frequency rates than existing systems. Digital data accuracy could vary based upon different logging methods. Multiple hardware and software solutions exist for collecting vehicle data. Desired data was collected from the vehicles utilizing Raspberry Pi3 as computing and processing unit as data acquisition solutions to quantify differences among collection methods. Two types of data were observed for this study. The first CAN bus frame data that illustrates data collected for each line of hex data sent from an electronic control unit. The second, OBD data that rep-resents some limited data that is requested from the electronic control unit un-der standard condition. Data log by the proposed system is a flexible (i.e. communicate with multiple electronic control units), modifiable (i.e. multiple input data simultaneously), multi-task, data dominant, latency sensitive, and a configurable device that can be fitted into any vehicle with minimum effort and mini-mum time lag in the data extraction process.

Keywords: Controller area network, Raspberry Pi3, On board Diagnostic (OBD), data accuracy, vehicle data extraction.

GeoDTC: A New Geographic Routing Protocol based on Distance, Time and Custody Transfer

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Abstract. This paper fits into the continuous efforts of researchers to propose a routing protocol able to successfully deliver data at an affordable cost under the challenging networks that are Vehicular Delay Tolerant Networks. Through the literature, several routing protocols based on various approaches have been proposed. However, during the last decade, the geographical approach emerged as the most natural to apply, due mainly to the popularisation of embedded GPS navigation systems. Despite this, and the proposal of different geographic based routing protocols for VDTNs, researchers are still looking for an ideal one, because of hard assumptions, limited performances or small and idealistic evaluation scenarios compared to real word environments. In this paper, we propose GeoDTC, a new geographic routing protocol dedicated to VDTNs, based on two distinct metrics namely: Distance and Time; jointly to the recurrent use of Custody Transfer. We conduct an extensive study to compare our proposal against well-knows protocols namely: Epidemic, Direct Delivery, GeoSpray and Prophet, under realistic simulation environment and scenario by using the large-scale dataset TAPAS Cologne. Simulations results reveal better performances for our proposal. Moreover, they demonstrate the potential benefits of intensive usage of the Custody Transfer and the introduction of various mechanisms.

Keywords: Vehicular Delay Tolerant Networks ,Routing Protocol , Geographic Routing Protocol , Vehicle To Infrastructure , Custody Transfer

User-centric vs Network-centric Vertical Handover Algorithms in 5G Vehicular Networks

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Abstract.
5G vehicular networks are designed to provide a guaranteed Quality-of- Service (QoS) in a heterogeneous wireless access technologies environment. In this case, the mobility management problem especially vertical handover decision should be carefully studied. In this paper, we work in a Software Defined Networking (SDN) environment. We propose two vertical handover decision schemes: user-centric where the handover decision is processed in the vehicles and network-centric where the handover decision is centralized in the network side. For both schemes, we use the Media Independent Handover for handover signaling and integrate the utility theory in the network selection calculation. Finally, we run several simulation scenarios in order to formalize a comparative conclusion about the proposed schemes.

Keywords: Software Defined Networking, Utility Theory, Vertical Handover, Media Independent Handover, User-centric, Network-centric

Dependability Aware Protocol for Urgency Messages Delivery in Internet of Vehicles

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Abstract. Over just one decade and due to their promising potential in greatly improving transportation usage, Vehicular Ad hoc NETworks (VANETs) have increasingly gained researcher attention in order to ensure them an expected and merited maturity. So, VANETs have been predicted to revolutionize transportation system domain giving them new dimension via Intelligent Transportation Systems (ITS) paradigm. ITSs suggest providing user vehicles with more safety, comfort, rapidity of moving, infotainment, etc. This undeniable advantage allows saving human lives, money, power consumption, time and making use of vehicles more attractive for passengers. This paper is dealing with dependable alert and urgent messages. So, when an alert is sent, we rely on that message to surely reach its destination in order that appropriate actions will be taken. Therefore, we devised a communication protocol ensuring emergency messages to be correctly delivered to their recipients in a way complying with real time requirements. The protocol is tested with repairing messages issued by failed vehicles and the simulation results provided by NS2-VanetMobiSim simulators are convincing.

Keywords: Emergency messages, Dependable delivery, Minimum network latency, Vanets, IoV

PART II. IoV clouds and services

Vehicular Fog Computing on Top of a Virtualization Layer

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Abstract. This paper presents a networking architecture that brings the principles of fog computing to the realm of vehicular ad-hoc networks (VANETs), by systematizing the use of one or more end-user clients or near-user edge devices to carry out tasks on behalf of others. The proposal is grounded on a virtualization layer and specific routing algorithms, adding new constructs and protocols to orchestrate the allocation of tasks and the sharing of resources. This proposal solves persistent problems of previous approaches to mobile augmentation in VANETs, which require the nodes offering their resources to stay close to the ones that would use them transiently. The advantages are proved by simulations of an application of collaborative mapping and navigation, in which the vehicles in a city share storage, computing and communication resources to distribute the tasks of (i) downloading, storing and sharing chunks of maps from a server, and (ii) computing routes to the intended destinations.

Keywords : fog computing, VANET, virtualization

Credit Based Incentive Approach for V2V Cooperation In Vehicular Cloud Computing

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Abstract. The Vehicular Cloud Computing (VCC) represents an important factor of smart cities through which Internet access can be offered to vehicular networks to store and download content via mobile gateways. The deployment of this service is focused on the exchange and the share of information between network entities. However, selfish nodes are an obstacle in a totally distributed network. As a solution, compensation could be provided to the vehicles that are willing to participate in VCC or to become an Internet gateway, while preserving their anonymity. Different credit-based incentive schemes are discussed in this paper. A scenario based on the Blockchain technology which implements a virtual payment service for the VCC members, for the resource consumption and for the gateway service in V2V routing mode, is proposed.

Keywords: IoV, Vehicular Cloud Computing, Communication, V2V, Routing, Mobile gateways , Incentive scheme , Cryptocurrency , Blockchain.

Vehicular Grouping and Network Formation: Virtualization of Network Self-Healing

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Abstract. The enhancement of vehicular network management and connectivity can significantly improve road safety and pave the way towards unmanned vehicular operation. Variable speeds and densities associated with constant movement of vehicles, changeable routes adopted by vehicles under diverse traffic conditions, would inevitably result in different dynamic vehicular network cluster formation/re-organization possibilities. Such dynamic re-organization for vehicular networks necessitates aspects of self-formation, self-joining and self-healing. Member nodes located in close vicinity to each other may formulate a group within the network. New members may join a group in case they arrive within close proximity of the group while existing members may depart in the event of change of route or if the group become distance away. The departure of a vehicle (an active network node) may create rupture in the data communication network operation. The paper presents the organization of vehicular network con-sidering the dynamic self-healing in the event of departure of a key network-connectivity component. The Contiki-Cooja simulation tool is used for implementation wherein various network scenarios are created to test and analyze the process. The results indicate the efficiency of election process at minimal network downtime. It also reflects how the network down time can be minimized or even totally removed using appropriate vehicular sensed parameters. The study also offers preliminary analysis to the impact of connectivity dynamics on the network re-organization process.

Keywords: Vehicular Network, Vehicular Grouping, Self-Healing.

Evaluate Good Bus Driving Behavior with LSTM

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Abstract. Drivers behaviors and their decision can affect the probability of the traffic accident, pollutant emissions and the energy efficiency level, good driving behavior can not only reduce fuel consumption, but also improves ride comfort and safety. In this paper, a new concept, evaluation zone, is defined to distinguish special driving areas, which has much influence on energy consumption, and ride comfort. Then, based on reducing fuel consumption and improving ride comfort, evaluation zone based driving behavior model is proposed to obtain good driving behavior dataset for the long short-term memory (LSTM) to apply the driving behavior evaluation and driving suggestion providing tasks. By using 687# bus lines driving data of Chongqing City, China, test results demonstrate that the developed model performs well and the LSTM could provide reliable driving evaluations and suggestions for drivers.

Keywords: driving behavior, long short-term memory, electric bus, driving suggestion.

Social Knowledge to Improve Situation Awareness of Assistance Systems in City Driving

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Abstract. City traffic is getting more multi-modal, with a variety of actors and mobility options in mixed spaces. This makes decisions on traffic behavior and control more complex. Beyond traditionally considered aspects (e.g. traffic state or used vehicle), human aspects (e.g. physical state, displacement goal, or companion), gain increasing relevance. They can greatly modify how people move and interact with others. Introducing social knowledge about human behavior and context can help to better understand and anticipate the environment and its actions. This paper proposes the development of Social-Aware Driver Assistance Systems (SADASs) for that purpose. A SADAS uses traffic social properties that formalize social knowledge using a template organized around diagrams. The diagrams are compliant with a specific modeling language, which is intended to describe social aspects in a given context. They facilitate the integration of this knowledge with system specifications, and its semi-automated verification both in design and run time. A case study on a distributed obstacle detection system for vehicles extended with social knowledge to anticipate people' behavior illustrates the approach.

Keywords: Multi-modal traffic, Mixed space, People behavior, Social knowledge , Traffic social property , Social-Aware Driver Assistance System.

Development of a mobile Functional Near-infrared Spectroscopy prototype

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Abstract. Driving is a complex and cognitively demanding task. It is important to assess the cognitive state of the driver in order to develop cognitive technical systems that can adapt to different cognitive states of the driver. For this purpose, we have developed a mobile functional near-infrared spectroscopy (mofNIRS) prototype. This paper describes the improvements of this mobile prototype with freely placeable optodes on a subject's head and the results of an evaluation study. We conducted a motor cortex experiment with four subjects, whereby the mobile prototype was mounted on the right hemisphere and a commercial, stationary fNIRS on the left hemisphere above the motor cortex area. One data set had to be discarded due to incorrect synchronization between both systems. The results of the remaining three subjects are presented and discussed in this paper. Here, we report the results from the time-series and Statistical Parametric Map-ping (SPM) analyses, which shows t-values with high differentiability of the Results. Furthermore, both analysis methods show comparable results between the commercial system and the mobile prototype.

Keywords: Mobile fNIRS prototype, motor cortical activity, validation study, driver cognitive states

PART III. Vehicular modeling and simulation

AMoDSim: An Efficient and Modular Simulation Framework for Autonomous Mobility on Demand

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Abstract. Urban transportation of next decade is expected to be disrupted by Autonomous Mobility on Demand (AMoD): AMoD providers will collect ride requests from users and will dispatch a fleet of autonomous vehicles to satisfy requests in the most efficient way. Differently from current ride sharing systems, in which driver behavior has a clear impact on the system, AMoD systems will be exclusively determined by the dispatching logic. As a consequence, a recent interest in the Operations Research and Computer Science communities has focused on this control logic. The new propositions and methodologies are generally evaluated via simulation. Unfortunately, there is no simulation platform that has emerged as reference, with the consequence that each author uses her own custom-made simulator, applicable only in her specific study, with no aim of generalization and without public release. This slows down the progress in the area as researchers cannot build on each other's work and cannot share, reproduce and verify the results. The goal of this paper is to present AMoDSim, an open-source simulation platform aimed to fill this gap and accelerate research in future ride sharing systems.

Keywords: smart mobility, smart city , shared mobility , autonomous vehicles , simulation

Aggregated Multi-Deep Deterministic Policy Gradient for Self-Driving Policy

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Abstract. Self-driving is a significant application of deep reinforcement learning. We present a deep reinforcement learning algorithm for control policies of self-driving vehicles. This method aggregates multiple sub-policies based on the deep deterministic policy gradient algorithm and centralized experience replays. The aggregated policy converges to the optimal policy by aggregating those sub-policies. It helps reduce the training time largely since each subpolicy is trained with less time. Experimental results on the open racing car simulator platform demonstrates that the proposed algorithm is able to successfully learn control policies, with a good generalization performance. This method outperforms the deep deterministic policy gradient algorithm with 56.7% less training time.

Keywords: Self-Driving, Deep Reinforcement Learning, Deep Deterministic Policy Gradient.

HESAVE: An Approach for Online Heuristic GPS Trajectory Sampling

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Abstract. In location based service system, online trajectory compression can help to relieve the whole system's pressure by reducing communication, storage and computation cost during network transmission, storage and business computing. Segment simplified sampling method is a kind of trajectory compression methods, which is widely used in online trajectory compression, but current methods have the problems such as temporal information loss and difficulty of parameter selection. In this paper, we propose an online heuristic trajectory sampling algorithm base on segment simplification, HESAVE (HEuristic SAmpling based on VEctor feature). HESAVE introduces Iterator Vector to de-scribe motion semantics of trajectory points. Furthermore, Iterator Vector In-formation is proposed to quantify the information of trajectory points based on Iterator. Moreover, HESAVE adopts a data-driven window called Sliding Mode Window to split multi-mode trajectory into isolated process units and a priority queue for each unit to select trajectory points. Extensive experiments on GeoLife 1.3 dataset show that HESAVE can gain more reservation of trajectory's temporal and positioning information after sampling under the same sampling ratio compared to SQUISH. In addition, HESAVE's computation resource consumption is quite acceptable.

Keywords: Trajectory Compression, Heuristic Sampling, Trajectory Vector Feature, Data-driven Window

Mobility as a Service enabled by the Autonomous Driving

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Abstract. The future of transport network fueled by vision of Autonomous driving is expected to revolutionize the classical ways of mobility. In this paper, we focus on enabling the autonomous mobility of specially enabled students within the Technical University Berlin Campus. In this connection, we digitize segments of the roads by deploying various sensors and communication infrastructure for V2X and sensors-to-central cloud communication. We present our vehicle disposition system for the so-called “Uni-Shuttle”, which integrates the various sensors information and optimizes the vehicles' schedules by means of local search operations and meta-heuristics. Our evaluation in a simulated environment shows that our approach is more efficient than a traditional bus with a fixed time-schedule and line network.

Keywords: Autonomous Vehicle, Street Digitization, V2X, Dial-a-ride

Adaptive Multiple Task Assignments for UAVs using Discrete Particle Swarm Optimization

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Abstract. The forest fire is an extremely dangerous natural disaster. The traditional fire-fighting equipment have great difficulty in performing firefighting in mountain terrain. Unmanned aerial vehicles (UAVs) are coming into a popular form in forest firefighting. In view of the suddenness of forest fires, the adaptive and dynamic firefighting task assignment for UAV is of great significance, and the current firefighting task assignment cannot address this issue. This paper proposed an adaptive and dynamic multiple task assignment method for UAVs. Firstly, the adaptive and dynamic firefighting task assignment is formulated as an optimization problem. Secondly, an assignment algorithm is proposed to solve the problem by extending the particle swarm optimization (PSO) algorithm. Finally, the experiment results verify the effectiveness of the proposed algorithm.

Keywords: UAV, Forest Firefighting, Task Assignment, Particle Swarm Optimization.

Autonomous vehicle traffic simulation at intersections

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Abstract. Following earlier research on anticipatory vehicular networks, this work-in-progress report presents a novel approach to autonomous traffic management at intersections. It is assumed that multiple ground-based autonomous vehicles operate in a heterogeneous environment, where they move along specified routes. Smooth operation of vehicles depends on their behavior at intersections where they must adjust speed or direction to avoid collisions and may stack in queues. In order to achieve traffic efficiency, we impose the rule that the traffic direction at intersections may be spontaneously assigned to one of the vehicles, termed virtual supervisor. Each vehicle communicates its movement parameters while all others within the communication range receive and store them in dedicated registers of anticipatory memory. Due to the harsh heterogeneous environment with disturbing external factors, the peer-to-peer communication is not perfect. The disturbances and other deficiencies of intervehicular communication can be compensated by anticipatory capabilities of vehicles. This traffic model is intended to manage cooperating mining vehicles that can communicate along a leaky feeder cable or directly, if in a visibility range. Supervisors provide guidance to vehicles within the anticipatory network framework. A simulation of a discrete-event model of the above situation shows that an ad hoc assigned supervisor capable of transferring signals by additional information channels and following the anticipatory control principles can considerably reduce the overall traffic uncertainty expressed by the expected number of collisions during the operation period. This observation, resulting from the simulation experiments performed in Matlab™, confirms the efficiency of the virtual supervisory control applied to different traffic management approaches.

Keywords: Autonomous Vehicles, Traffic Management at Intersections, Anticipatory Networks, Simulation

PART IV. Vehicular security and privacy

Towards the security measures of the Vehicular Ad-Hoc Networks

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Abstract. The vehicles currently manufactured are becoming progressively associated with the Internet, supporting a variety of new highlights that are valuable towards both drivers and automakers. Therefore, the highlights given entail the new security issues. Vehicular Ad-Hoc Net- works (VANET) have recently emerged as one of the solutions that could help connecting cars to the vast network. Not only could preserve the safety, but also the efficiency of the traffic. The paper focuses on the VANETs that are vulnerable to attacks, which can directly lead to the corruption of networks and then possibly provoke a considerable loss of time, money, and even the users' lives. The analysis of the Sybil attacks is presented and the possible solutions that could solve the security leaks in vehicle networks are proposed.

Keywords: Car network, Vehicular Ad-Hoc Networks (VANETs), Car security, Privacy, Security attacks

Electric Vehicle Charging Queue Management with Blockchain

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Abstract. We will have to build adequate charging station infrastructure to support the massive proliferation of electric vehicles over the next few years. A federated structure for charging stations can serve as a solution for building a large number of charging stations. It will allow microgrids, private houses, and hotels to provide charging services. Present literature on the topic of managing electric vehicle charging queues has not addressed the problems associated with such a federated network of charging stations. In this paper, we solve the electric vehicle charging queue management problem through a federation of charging stations using blockchains. In this electric vehicle queue management solution, we show that (a) stations cannot hide information to manipulate charging queues, (b) it enhances the privacy of electric vehicles as they are not required to reveal their exact desired recharging locations, (c) it encourages electric vehicles to recharge at the prescribed charging stations, (d) it allocates better recharging stations to electric vehicles who reveal their exact desired recharging location, i.e., one pays for privacy, (e) it supports load balancing over stations, and (f) blockchain not only provides a transparent and secure solution but also provides incentives to the station owners to bear the cost of establishing a charging station.

Keywords: Electric vehicle, Charging station, Blockchain

Towards a blockchain-based SD-IoV for applications authentication and trust management

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Abstract. IoV, bringing smartness into the vehicular environment, represents the future of the vehicular networks. To improve the IoV network management, resource utilization and QoS, a new architecture integrating the SDN technology have been proposed: SD-IoV. However, this architecture introduces new threats and, in particular, security is an important challenge. One of the major shortcomings with security is the lack of authentication and authorization of the applications (network, third party or user) at the distributed SD-IoV control layer. Indeed, these applications are currently able to control the SDN controllers and therefore the network behavior without any restriction. Consequently, a malicious or compromised application could easily disturb the entire network. That is why this paper proposes an innovative trust establishment system based on the blockchain technology. This system aims to control the application identity, as well as the application behavior and the network resources allocation and management. The ideas of application identity and application trust index, using the distributed nature of the SD-IoV, are introduced. Moreover, a design of this system, using smart contracts is also presented.

Keywords: Internet of Vehicles, SDN, SD-IoV, Blockchain, and Security

A Secure Authentication Protocol for Wireless Sensor Network in Smart Vehicular System

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Abstract. As wireless sensor networks (WSN) and Internet of things (IoT) have rapidly developed over recent years, the smart vehicular system is designed in the environment of WSN to provide vehicle related applications such as traffic safety for drivers, controlling traffic signal, broadcasting traffic information and speed monitoring etc. Recently, Mohit et al. have proposed an authentication protocol for WSN-based smart vehicular system. Their protocol consists of three main entities namely vehicle sensor, sink node and user. Vehicle sensors collected traffic data and send it to a sink node of WSN. User used traffic data from sink node in off-line mode for the traffic management. Mohit et al. claimed that the proposed protocol is secure against various attacks such as untraceable, impersonation and password guessing attacks. However, their proposed protocol still has some vulnerabilities such as absence of session key, suffering user duplication and sink node impersonation attacks. Thus their protocol cannot guarantee complete security. In this paper, we aim to propose an improved protocol based on their work, which overcomes these security loopholes in their protocol. The informal security analysis shows that our proposed protocol is cable to defend the security weaknesses found in Mohit et al.'s authentication protocol.

Keywords: Authentication; Internet of Things; Session key; Smart vehicular system; Wireless sensor network.

An Acceleration Method for Similar Time-series Finding

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Abstract. Finding a time series subsequence that is similar to a specific time series is an important problem in trajectory data of vehicles analysis. The problem is made significantly harder for the massive and high-dimensional features of time series. The existing methods for finding the similar subsequences in time series have high time complexity and poor applicability to similar subsequence finding of different lengths. In this paper, we propose an acceleration method for similar time-series finding to address this issue. Firstly, our method defines and extracts the feature of the query sequence. Then, we use the feature as the key to search sequence with the same feature to form a candidate set. After that, in each sequence in candidate set, we filter the important points and add it into feature points list to hold the shape characteristics of original sequence better. Finally, Dynamic time warping (DTW) is used to find the similar time-series. Experiment results illustrate that the proposed method can improve the search efficiency and accuracy.

Keywords: Time Series; Similarity Searching; Dimensions Reduction; Acceleration Method

The current security challenges of vehicle communication in the future transportation system

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Abstract. In a near future, an intelligent traffic system everywhere with early warning signals for drivers, it can help to minimize vehicle collision; increase the safe road; decrease the fatal injury for the pedestrians, passengers, and drivers; and inter-vehicle communication. These are some benefits of vehicle-to-vehicle communication (V2V). With the developing of this technology, these vehicles can communicate together and with infrastructure or Road Side Units (RSU). In this article, the authors explored the basic concepts and the benefits of vehicle-to-vehicle communication. Moreover, this paper points out several security concerns toward Vehicular Ad hoc Network (VANET) system, vehicle to vehicle and vehicle to infrastructure communication.

Keywords: security challenges, VANET, vehicle communication, V2V security.