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Intelligent VANETs: A Survey

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Abstract— With the dramatic increase of modern economical and technical development, Intelligent Transport System today has become more and more important and essential. It is an intelligent approach that deals with information, communications and satellite technologies in meeting out traffic safety, congestion control and improving environmental quality. Since the urbanization is under remarkable development for the past years, traffic problems like congestion, accidents and environmental pollution has affected the metropolis in greater numbers. There are many existing problems that we cannot meet out with mere transport infrastructure and expansions. At the same time, advances in wireless communication technologies have enabled vehicles on a highway to communicate in order to share their status information and provide drivers with potential collision warnings, regulates traffic problems, etc. This paper bridges the dilemma between the various applications that are available for Intelligent VANET and also discusses the realistic vehicular Network Characteristics with the ad hoc transportation systems that can overcome many problems and will help to ease the needs of the prevailing scenarios.

Keywords— ITS, Intelligent Vehicles, Vehicular ad hoc networks, Vehicular applications

I. INTRODUCTION

Intelligent transport systems (ITS) combine advanced information technology, telecommunication technology, sensor technology, control technology and computer technology to an integral transportation management system, which is built on a larger scale. Intelligent VANET aims at providing modern creative services relating to different modes of transport and traffic management, to enable various users to be best informed and to make use of transport networks more safely and more efficiently (Yuxiang Yan, Chenxue Xu, 2013). The Potential of Intelligent VANET is to help realize broader transport policy goals lies in their wide variety of applications in the different modes of transport for both passengers and freight.

With the dramatic increase in the population and the expansion of cities' scales, the largest cities are facing serious traffic problems. These problems, such as congestion, pollution and accidents are becoming one of the most significant bottlenecks that restrict the development of these cities. The high quality of life, making places accessibility and bringing people and goods together are the signs of a excellent intelligent system (Sadayuki Tsugawa, Shin Kato, 2010) .Traditional traffic solutions, such as building the city expressway system, enhancing the density of the road, metro constructions, which have taken some periodical effect, show their limitations when dealing with the dilemma cities confront today (Yuxiang Yan, Chenxue Xu, 2013). Projects like GPPQ which targets European continent is working hard in developing applications and remedies to reduce the fuel consumption and congestion control as the oil resources will become scarce in future. Other notable project such as ITIF which has carried out major works moved and raised the need for applications in Intelligent Transportation Systems. Intelligent VANET is more widely applied to address the traffic problems and provide a safer, more efficient and more economic transportation system, contributing to create a better city (Stephen Ezell, 2010).

II. APPLICATIONS FOR INTELLIGENT VEHICLES

Intelligent Vehicles will be provided with unique computing, communication, and sensing capabilities. These will support a spectrum of applications, based on Vehicular Communication range from simple exchange of vehicle status data to highly complex Large scale traffic management including infrastructure integration that enhances transportation Safety and efficiency, but also provide new or integrate existing services for the drivers and passengers (Elmar Schoch, Frank Kargl, Michael Weber, 2008). A significant role is envisioned for existing or upcoming wireless infrastructure (e.g., cellular), connectivity to the wire line part of the Internet, and dedicated roadside infrastructure units (RSUs). User-portable services are also expected to be wirelessly attached to the onboard equipment (Panos Papadimitratos, 2009)

The applications presented in Table 1 are compiled from several sources. Intelligent VANETs applications can be readily divided into a) systems which provide an advisory/warning to the driver (collision warning system), b) systems which take partial control of the vehicle either for steady-state driver assistance or as an emergency intervention to avoid a collision (collision avoidance), c) systems which take full control of vehicle operation (vehicle automation). The chosen classification scheme groups applications by their purpose, which leads to groups of logically similar applications. Other notable projects like COM2REACT focuses on cellular and V2V communication, in-car and V2V communication systems, Vehicle to Center Communications (Richard Bishop, 2000). Cooperative Architectural projects like GeoNet

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focuses on the Geo-Networking and Cooperative driving. Data protection between intra vehicles is in active progress (EVITA). There are many other active ongoing projects namely HAVE-IT, ETSI-TC-ITS, CYBERMOVE, CVIS and COOPERS which focuses on building up a more reliable communication medium for disturbance free communication system.

TABLE I: OVERVIEW OF APPLICATIONS FOR INTELLIGENT VEHICLES

	Situation / Purpose	*Application Examples*
Intelligent Vehicles	***Collision Avoidance***	***1. Intersection Collision Warning, 2. Obstacle Detection, 3. Lane Change Assistance, 4. Lane Departure Warning, 5. Rollover Warning, 6.Road Departure Warning, 7. Forward Collision Warning, 8. Rear Impact Warning***
	Driver Assistances	***1. Highway Merge Assistance, 2. Driver Communication, 3. Vision Enhancement, 4. Object Detection, 5. Adaptive Cruise Control, 6. Intelligent Speed Control, 7. Lane Keeping Assistance, 8. Roll Stability Control, 9. Drowsy Driver Warning Systems, 10. Precision Docking, 11. Parking Spot Locator, 12. On-Board Monitoring***
	Collision Notification	***1. Emergency Response, 2. Support for Authorities***

III. COLLISION AVOIDANCE

Collision Avoidance applications are considered as the typical and most desired group of applications for Intelligent VANETs with direct impact on road safety. In other words, it can be a system that is used to reduce the severity of an accident (Sheng-hai An, Byung-Hyug Lee, 2011). Fig 1. Shows how a pre-crash is detected. The main intention behind the Collision avoidance application is to safeguard the vehicle and the driver about a collision situation by means of communication. Generally, these applications will sense a hazardous situation coming ahead and it alerts the driver about the situation and thus a pre dominant collision is sensed and prevented. These applications will also act accordingly when an unstoppable incident occurs (Siim Kallas, 2011). It is also known as the pre-crash warning system that uses radars, lasers to foresee imminent crash. Once the pre-crash warning system spots a problem, it does two things a) it immediately alerts the driver about the sensed situation or b) it takes an alternative and takes control over the vehicle for the next safe action.

The Pre-Crash Collision Avoidance system extends its features that it can detect the possibility of a pedestrian with the help of radar or dedicated short range radio waves. About 40 % of the collision involving pedestrians are avoidance as the speed of the vehicle is low and 60% is unavoidable since the vehicles are travelling at a very high speed (Huang Zhu, 2010). Forward Collision Warning and Rear Collision Warning applications are the extended form of Pre-Crash Warning application that it can sense the rear colliding situations. On the road, every move a driver makes can significantly impact everyone in the area. A lane change or turn might seem simple but if made at unnecessary venues causes heavy damage to the succeeding vehicles.

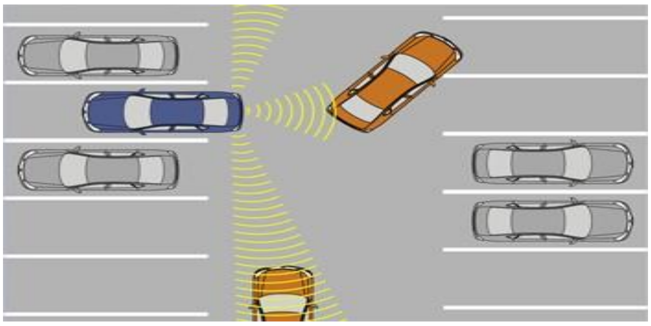

Fig. 1 Collision Avoidance Sensor

IV. DRIVER ASSISTANCES AND COLLISION NOTIFICATIONS

This category contains applications that try to improve or simplify driving by means of communication. Helper applications are intended to assist the drivers with standard traffic situations. The Intelligent VANET Drive Assistance system makes the driving safe and convenient (Khekare, 2013). It monitors the traffic situations and assists the drivers. The highway merge assistant keeps the vehicle reliably in lane; the active system gently influences the steering to send the vehicle back in the right direction. Park Assist calculates the ideal parking maneuver for any suitable space in a matter of seconds the system automatically maneuvers the car into the parking space. The fatigue detection system identifies changes in the driver's normal responses. If fatigue is detected, the driver is alerted and automatic braking is activated (Vladimir, 2010). Timely notifications about lane change, emergency and unsafely approaching vehicles can be identified and the notifications are made to the driver.

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V. NETWORK CHARACTERISTICS

The major set of constraints to the development of applications, irrespective of message dissemination methods and security mechanisms is given by the network characteristics, which makes VANETs a very distinct category of ad hoc networks (Miguel, Jens, 2011). The categorizations and elaborate development consequences are discussed below.

A. Node Velocity

The most important aspect in Intelligent VANET is its mobility. Every Mobile node travels in a particular speed which is its node velocity. A node in general denotes both mobile nodes and static nodes. Static nodes can be a Road Side Unit (RSU). Since the RSU are static nodes, they have the node velocity equals to zero. Other mobile node velocity may vary from zero to 200km/hr (an achievable speed by the vehicle) (Junping Zhang, 2011). Various issues have been addressed in this regard, a high speeding vehicle communicates with a stationary node and updates its status and location information but due to the high speed of the vehicle, the transmission may not last longer. Thus there exists a less topology dynamics among nodes. Considering the other extreme with no mobile nodes in the network topology or slow moving nodes, it means there is an ample vehicle density and thus leading to congestion (Sooksan, was an, 2011).

B. Movement Patterns

Vehicles move in random directions, they only change directions when they encounter an intersection. Vehicles do not move arbitrarily and do not bind to a unique topology (Li, Tang, 2009). Their speed and directions always depend on the types of roads they travel in.

1) *Dense City Roads:* The roads inside the cities are relatively dense in nature. There are lots of smaller roads and junctions and intersections inside the cities. Fig 3 shows the dense road conditions in cities (Sebastien, Benoit, 2010). These dense road conditions affect the vehicle speed and thus traffic interference occurs. The result of which is congestion, traffic jams.
2) *Highways:* Highway roads or Smart roads are well defined roads that have multi lane systems. The Roads are broader and segmented to ease traffic flow and thus holds many flexible road features (Zhao, 2000). The direction of vehicles in the highways is usually uni-directional. There are not much smaller roads or diversions often. Traffic jams occur occasionally when crashes happen. Fig 2 shows structured road intersections in highways.
3) *Rural Roads:* The larger segmented roads which are not properly structured. Intersections and dense road conditions are rarely seen (Filali, Bonnet, 2009). The use of communications in Vehicles and their dependencies towards RSUs are relatively lower because of free road conditions that prevail in rural areas.

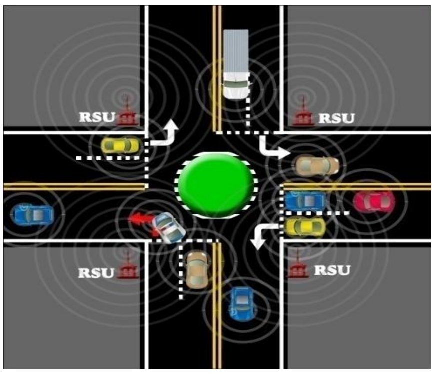

Fig. 2 Highways Intersections

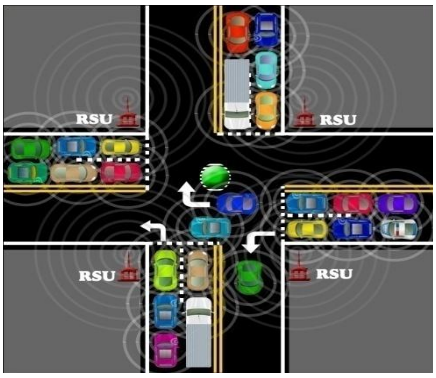

Fig. 3 Dense City Conditions

C. Node Density

The third key property of the vehicular mobility is the node density. In a mutual radio range, the number of vehicles may vary from zero to hundred. Imagine if a traffic jam occurs in a highway, automatically the node density becomes high and it becomes very difficult for a vehicle to communicate its data with the nearby vehicles or the RSUs (Maazen, 2013). In the case of low node density, it is still a question because the immediate message forwarding becomes a question. In addition, node density is not only correlated to the type of the road, but also to time. The node density on a highway will not be the same in the daylight and the night time.

D. Node Heterogeneity

There are some basic differences between a vehicle and RSUs. Vehicles can be categorized into private, authority, maintenance and construction vehicles (Takatori, 2011). It is not important that the entire vehicle should hold the same applications installed. An Emergency vehicle should be able to issue warnings about its approach to the participating vehicles and the RSUs. Depending on the nature of the vehicle, the infrastructural nodes will emit data to the network.

VI. CONCLUSIONS

As a prospective technology, Vehicular Ad Hoc Networks (VANETs) have recently been attracting the attention from both research and industry communities. One of the fastest growing domains in VANETs is safety, where communications are exchanged in order to improve the driver's responsiveness and safety in case of road incidents. The characteristics of VANETs are a higher mobility and whereas they have limited degree of freedom in the mobility

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patterns (Filali, 2009). This article surveyed the recent efforts of the ITS related systems and technologies and concerted efforts have yielded significant results and momentum for further developments. The different types of applications envisioned for Intelligent VANETs result in a challenging tasks for the creation of suitable communication mechanism to enable these applications (Baskar, 2009). The introduction and deployment of the vehicular communications should begin with a service that is effective even at a low penetration rate of communication units. In this paper, we have classified a variety of applications. In addition, network characteristics and nodes based on which the proposed applications can be built in the future.

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