International Journal of Innovations in Engineering and Technology (IJIET)
http://dx.doi.org/10.21172/ijiet.93.07

# Recent Advances In Vehicle To Vehicle Communication: Survey

T.Prabhu[1], K.S.Adhith Gowtham[2] , S.Gowtham[2], D.Jeevitha[2], R.Jeevithra[2]

[1]*Assistant Professor, Department of ECE, SNS College of Technology, Coimbatore.*
[2]*UG Students, Department of ECE, SNS College of Technology, Coimbatore.*

**Abstract−Recently Vehicle to Vehicle communication have attracted great interest due to the potential to improve traffic safety, reduce energy consumption, and enable new services related to intelligent transportation systems. V2V is emerging as an effective technology for providing a wide range of safety applications for vehicle passengers. Connected vehicles could dramatically reduce the number of fatalities and serious injuries caused by accidents on roads. V2V communication also has a bigger impact than the advanced vehicle automation technologies that have been more widely heralded. Creating a vehicle to vehicle network is still a complex challenge. This paper is devoted to provide a structured and comprehensive overview of recent research advances on V2V, driver assistance, collision warning, intersection avoiding, location tracking, Radio Resource Management [RRM] for better performance, trajectory following, improved traffic management, providing a safety service models, emergency services assistance.**

**Keywords- Vehicle-to-Vehicle communication, trajectory following, RRM, intersection safety, GPS**

## I. INTRODUCTION

Due to the recent technological and population development, usage of vehicles is rapidly increasing and at the same time the occurrence of accidents has also increased. The traffic problems are not only problems of individual countries, but also a global topic. The ITS technologies must be more useful, safer and provide two efficient models for vehicular communications such as an intelligent model and an integrate model to solve the traffic problems [1]. Federal officials have conducted several driver clinics over the past year in which public volunteers have been able to experience the technologies and those features may avoid accidents too. The features include intersection assist, left-turn assist, do-not-pass warning, advance warning of a vehicle breaking ahead, forward collision warning, blind-spot/lane-change warning. Vehicle-to-vehicle communication systems are designed to prevent crashes in number of scenarios. Vehicle-to-vehicle communication is more accurate than current blind-spot monitoring systems that uses cameras or radar and can even warn us of a car that's accelerating into our blind zone, which conventional systems can't do.

Considering the traffic dangers and other problems, trajectory following control based on V2V communication is provided [2]. The vehicle kinematics model is key factor to establish the trajectory following control. The kinematics model may monitor the speed and movement of data in a single vehicle. It realizes fleet control. Along with the behavior of fleets, the collaborative driving mainly adapts five strategies including cruise, tracking, combination, splitting and lane changing which control vehicle, fleets and environment state based on data sent by Wireless communication networks. With the help of movement of data on front vehicle obtained using Carsim, a simulation model of following system is established through Simulink components in MATLAB and gain the movement of data on following vehicle according to the front vehicle. By analyzing the movement of data on both the front and the following vehicle, the predictive control of vehicle model predicts the feasibility of reference trajectory tracking in the quadratic programming method. The result is verified to be stable and feasible at low speed. Many techniques have been proposed to reduce intersection accidents. Such techniques include collision models and probability at intersections proposed using MATLAB simulations. Results would be better if the information is directly shared by utilizing Wireless Local Area Networks (WLAN). Wireless Access in Vehicular Environment (WAVE) based on WLAN is a representative technique in vehicle-to-vehicle communication which provides a safety service model that assists the vehicular movement in unsignaled intersections [3]. The WAVE receives the chassis information through the Controller Area Network (CAN). The safety service model consists of GPS for positioning. The GPS can receive the position information from satellite and relay the GPS data to WAVE through Ethernet. WAVE equipped with mathematical model and HMI linked through Bluetooth inform drivers the dangerous situations. This system provide host drivers with warnings by predicting the collision time between the host vehicle and other vehicle through a mathematical model to avoid intersection accidents during traffic.

The efficient use of system radio resources is correlated to the desire of the network operator with a high level of satisfactory network coverage and a wide range of affordable services with supported QoS requirements. The Device 2 Device link is a promising enabler for V2V communication application as it meets the requirements of QoS [4]. Radio Ressource Management design is necessary when applying D2D network to V2V communication. Separate resOurce bLock and powEr allocatioN [SOLEN] algorithm solves the radio resource management of latency and reliability requirements of V2V communication. Handling the task of collision prevention requires information about the location and motion parameters of all cars within a certain limited areas. By using differential GPS, we can achieve nearly acceptable accuracy of about 1m. The potential collision warning algorithm is used to control the unexpected intersection of the vehicles based on the data received from GPS navigation system and V2V communication [5]. The performance of the system was based on various acceleration values of starting vehicle, which is shared for better V2V communication.

## II. THE DEVELOPMENT OF V2V IN VARIOUS COUNTRIES

As a basis for traditional traffic engineering V2V communication developed a new transport system. Because of various national circumstances, development priorities are different and the contents of the V2V research are also not the same. Generally, V2V is recognized as using information, communication, control and other current technologies to establish a real-time, accurate and efficient transportation management system.

### *A. United States*

The global V2V market, by geography, has been segmented into North America, Europe, Asia and rest of the world. As compared to other regions, V2V communication market in North America is expected to witness significant growth and hold the largest market share during forecast period. U.S and Canada are anticipated to drive the growth of V2V communication market, out of which U.S is majorly dominating the global demand for V2V Communication market. This is owing to the presence of large number of established key players like General Motors and Qualcomm Technologies in that region.

### *B. European Union*

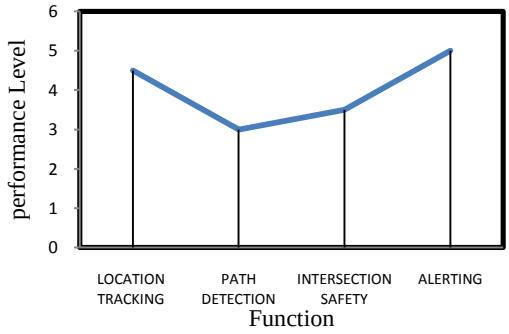
In the global Vehicle to Vehicle communication market Europe is anticipated to witness relatively faster adoption and is expected to grow at the highest CAGR during the forecast period as compared to the other region. Within Asia, Pacific, V2V communication market is projected to contribute faster to the growth of revenue backed by increasing number of vehicles and growing adoption of technological advancement in the region. In the terms of revenue, North America is followed by Europe region. This is owing to the presence of Key players like BMW, AUDI, DAIMLER and VOLKSWAGEN in the region.

## III. ASSESSMENT OF KEY UNDERLYING TECHNOLOGIES

In this section, many key underlying technologies for V2V communication, such as Integrate model of ITS, Trajectory following, Intersection safety model, RRM for D2D and GPS navigation are described.

### *A. Integrated model of ITS*

Many technologies are needed to integrate to achieve ITS. If the integrated model system comes true, it is believed that most of current transportation problems can be solved. Smart way technology, which makes major advances over the VICS service, can offer traffic information, location and contextually specific information to drivers. If vehicles are coming upon the area which belongs to particular accident prone areas, the system will warn the drivers. With the Smart way and the intelligent vehicle's early warning system, many accidents can be prevented before happen. The Model which integrate the advantages of many countries' ITS technologies such as Japan's Smart way, United States' VII, European Union's CVIS(Cooperative Vehicle Infrastructure Systems), COOPERS(Cooperative Systems for Intelligent Road Safety) is a more useful, safe, efficient ITS transportation model.




Fig, 1 Function measures of ITS

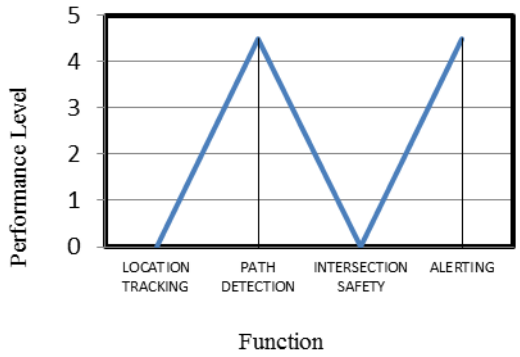
| **FUNCTION** | **PERFORMANCE LEVEL** |
|---|---|
| Location Tracking | 4.5 |
| Path Detection | 3 |
| Intersection Safety | 3.5 |
| Alerting | 5 |

Table 1 Performance level of ITS

*B. Trajectory following*

Trajectory following control based on V2V communication method, stable the vehicle. It uses wireless technology, sensor technology to detect vehicles, also complete co-operation and co-ordination between vehicles is achieved, in order to achieve the road safety. Here MPC (Model Predictive Control) controller will plan the path according to the real time signal received from the front vehicle. The front vehicle is a reference trajectory[2].According to the updated status information of V2V communication MPC controller predicts the next time domain output and repeat the process until control process is completed; i.e. movement data of the following vehicle.

*1) Tools used:* MATLAB and carsim are jointly used to realize the simulation experiment of Trajectory following. Carsim processes the data obtain from the front vehicle.MATLAB establish the simulation model of the system through simulink.



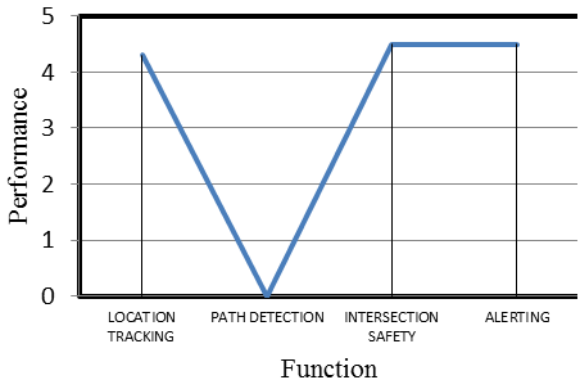

Fig,2,Function measures of trajectory following

| FUNCTION | PERFORMANCE LEVEL |
|---|---|
| Location Tracking | 0 |
| Path Detection | 4.5 |
| Intersection Safety | 0 |
| Alerting | 4.5 |

Table 2,Performance level of Trajectory Following

*C. Intersection safety model*

Intersection safety service model using V2V communication is for safety service and it also assists the vehicular movement in unsignaled intersections. It uses WAVE protocol. Here the host vehicle recognizes collision probability. The WAVE can communicate with surrounding vehicles by using WAVE module. The WAVE receives the information through CAN. The position of the vehicle is obtained from GPS. If any dangerous situation was recognized by safety system warning message is displayed on HMI (Human Machine Interface), linked through Bluetooth [3]. This system predicts collision time between host vehicle and other vehicle that approach from left and right sides through mathematical model.



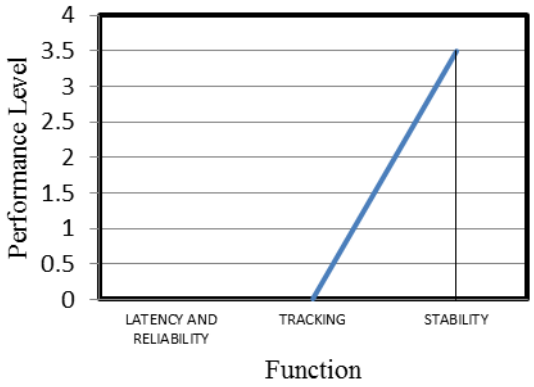

Fig, 3 Function measures of intersection safety model

| FUNCTION | PERFORMANCE |
|---|---|
| Location Tracking | 4.3 |
| Path Detection | 0 |
| Intersection Safety | 4.5 |
| Alerting | 4.5 |

Table, 3 Performance level of Intersection Safety Model

*D. RRM for D2D*

Radio Resource management for D2D based V2V communication analyze and transform the latency and reliable requirements of V2V communication. The performance for vehicular communication is not always satisfactory, especially in terms of latency and reliability. Therefore, there is a strong desire of finding better solutions to support V2V communication. Device-to-device (D2D) communication is identified as one of the technology components for future cellular systems. Extensive researches have been carried out in the context of traditional D2D systems, where one of the most critical challenges is the interference between the primary cellular network and the D2D underlay. To cope with this new interference situation, one crucial issue is the RRM strategy, The problem under study is centralized RRM for D2D based V2V communication with strict latency and reliability requirements and with access only to slowly time-varying CSI (Channel State Information).SOLEN algorithm gives optimal solution for each stage, which to some extend promises good performance of the SOLEN algorithm, which is indeed confirmed by numerical results [4]. Due to the similarity between the QoS requirements of V2V application and the benefits of D2D communication, the direct D2D link is a promising enabler for V2V communication as long as the RRM is conducted in a careful way. The actual latency and reliability requirements of V2V communication into optimization constraints are computed from only slowly varying CSI. This transformation allows applying certain existing D2D schemes to V2V communication, Numerical results confirm that careful RRM design is necessary when applying D2D network to V2V communication.



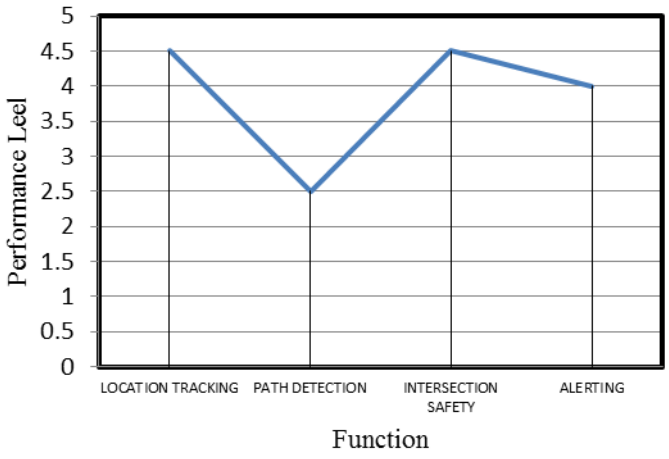

Fig, 4 Function measures of RRM for D2D

| FUNCTION | PERFORMANCE LEVEL |
|---|---|
| Latency and Reliability | 0 |
| Tracking | 3.5 |
| Stability | 4.5 |

Table 4, Performance Level of RRM for D2D

*E. GPS Navigation*

The uncontrolled intersections are the most dangerous sections of a motor road. Entering an intersection from a side road is a difficult task for a driver. This significantly increase the road accidents .Handling the task of collision prevention requires information about the location and motion parameters of all the cars. The task of determining the location of the car is handled by GPS. Using embedded GPS receivers in vehicles' on-board units to receive signals from several different satellites to the position vehicle. This requires lines of sight to satellites, which can hold back the usage of GPS in downtown settings because of "urban canyon" effects. Location can usually be done with the limit of ten meters. GPS is a core technology behind many in-vehicle navigation and route guidance systems. To determine the car's safety criterion, the car's orientation in X-Y plane should known it is determined by course angle ϕ,[5] this gives the car's geometrical model, which is sufficient to solve the task of collision prevention. Here the movement through the intersection from the position of a full stop directly and with a turn to the left was considered.




Fig, 5 Function measures of GPS navigation

| FUNCTION | PERFORMANCE LEVEL |
|---|---|
| Location Tracking | 4.5 |
| Path Detection | 2.5 |
| Intersection Safety | 4.5 |
| Alerting | 4 |

Table 5,Performance Level of GPS navigation

## IV. V2V TOOLS

V2V holds the promise of making driving experience safer and more efficient. There are many performance metrics that need to be evaluated to assess the performance of V2V communication. For example, one of the key performance metrics is the time takes to deliver the message to vehicles in the vicinity and the route of incident. Other examples include the time it takes to setup a reliable connection and its capability to support online traffic conditions. It is essential to evaluate such performance metrics before deploying the V2V connection, especially in large cities, and assess the benefit of deployment because of high cost to realize and test them using real time experimental setups. Hence there is a strong need for V2V tools to prototypes the vehicular communication.

### *A. V2V Simulation Tools*

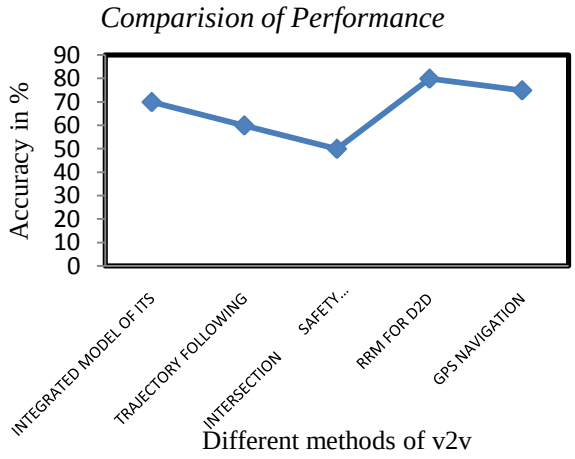
In vehicular technology, CarSim provides a promising way to analyze vehicle dynamics, developing active controllers, calculating cars performance characteristics. The motive of the CarSim is to simulate the performance of passenger vehicles and light duty trucks. This tool works as standalone application, not require any other software to perform simulation. It's standard interface to MATLAB/SIMULINK. It supports vehicle sensors and interactive traffic for V2v and ADAS development. CarSim is used by 7 of the 10 largest automotive OEMs as it is economical in comparison to other commercial vehicle dynamic software tools.

As CarSim is interfaced with MATLAB/SIMULINK, let us see the performance based on both MATLAB and SIMULINK. MATLAB is environment for technical computing; explore, analyze and visualize data, develop algorithm, interactive graphics and custom deployable tools. SIMULINK is only one tool box from MATLAB family; it means to run SIMULINK we need to install MATLAB before. SIMULINK is environment for model based, system level designing; model, simulate, analyze and implement dynamic, multidomain system. The main MATLAB program has only one command line oriented interface. SIMULINK has a graphical interface, where we can draw our elements like in a plan. Let us choose the benefits of interfacing CarSim with MATLAB/SIMULINK based on comparison

### *B. Comparison of tools*

| TOOLS | ABOUT | PERFORMANCE |
|---|---|---|
| MATLAB | Model based design | Moderate |
| SIMULINK | Both model based design and system level design, graphical interfacing is ease | High, as it review result and validate systems. |

Table 6, Comparision of Tools




Fig, 6 Overall comparisons

| FUNCTION | ACCURACY IN % |
|---|---|
| Integrated Model Of ITS | 70 |
| Trajectory Following | 60 |
| Intersection Safety Model | 50 |
| RRM for D2D | 80 |
| GPS Navigation | 75 |

Table 7, Accuracy levels of different methods

## V. CONCLUSIONS

The main motive of this survey paper is to explore the current ideas in vehicular communication. This paper investigated a detailed survey on the vehicle to vehicle communication technologies, and its applications such as alerts and warning, driver assistance, traffic optimization and control commands and it also measures the performance level of several techiques.V2V communication presents a lot of very exciting changes in the near future with the potential safety improvements acting as the driving force behind its adoption.

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