In the name of God

Connected Vehicle Technology Project in I.R.IRAN

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ABSTRACT

ACECR (Academic Center for Education, Culture and Research) -Sharif Branch in cooperation with IDRO (Industrial Development and Renovation Organization of Iran) has devoted extensive efforts in *Design and Implementation of Vehicular Intelligent Transportation System Project* aiming to improve driving safety, traffic management improvement and reducing vehicles fuel consumption in I.R.IRAN. Following the primary researches, producing software applications and conducting experimental and field tests, the project is now in its pilot phase. By successful implementation of defined applications in the pilot, stakeholders' cooperation has been obtained in order to prepare a road map for vehicular communication technology development in the country [1].

Keywords: Connected Vehicle Technology, DSRC, V2I, V2V, Traffic Safety

1. INTRODUCTION

The Ministry of Roads and Transportation research center of Iran has reported that between 1994 and 2008 the country was on top of the list of road fatalities in the world. Increasing problems of urban traffic management, steering vehicles in the roads and heavy financial and human costs of these problems as a big challenge, and at the same time the advances in communication and information technologies as an advantage, necessitates the application of vehicular intelligent communication technologies in transportation.

These problems raised a concern in ACECR-Sharif Branch to participate in the general endeavor to diminish vehicular hazards and their related side-effects in the country. Hence, ACECR-Sharif Branch initiated the project of Design and Implementation of Vehicular Intelligent Transportation System Project named CVT (Connected Vehicular Technology) project sponsored by IDRO. During the implementation of this project, required communication infrastructure has been established in order to receive and transmit safety messages in vehicles moving in urban crossings and intercity roads. Through conducting the CVT project, we intend to 1) localize the technical knowledge of vehicular communication technology, 2) examine feasibility and analyzing the results of 9 defined applications in the operational scenarios according to the specified requirements of each application stipulated in the CRS (Customer Requirement Specification) document, 3) create convenient conditions for collaboration with corresponding stakeholders 4) develop a road map for development of this technology in the country and 5) make the public opinion familiar with various aspects of vehicular communication systems.

CVT is a technology consisting of capabilities based on DSRC technology which serve as an infrastructure to transmit and share data between vehicles and traffic control equipments. CVT offers various services in areas of safety, traffic management and commercial. Fig. 1 shows an overall view of architecture of connected vehicle technology.

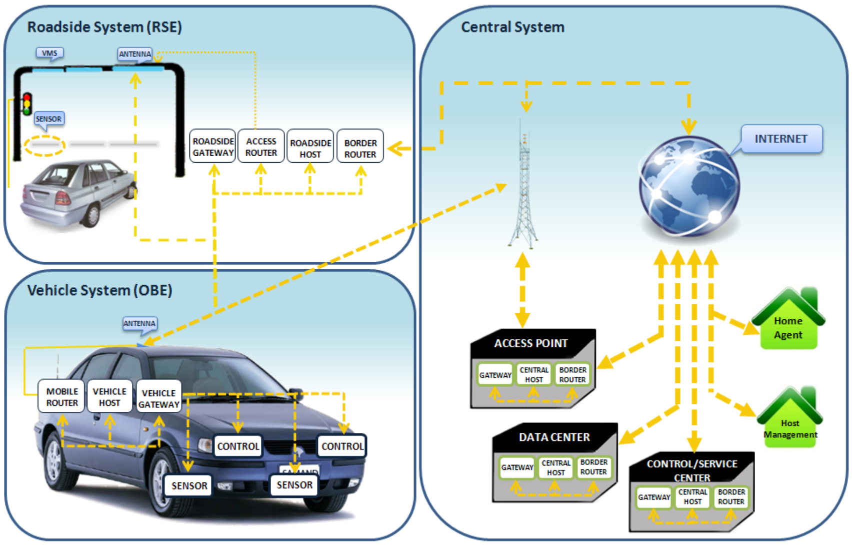

Figure1. A view of the architecture of the system

Dedicated short-range communications (DSRC) are one-way or two-way short-to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. In October 1999, the United States Federal Communications Commission (FCC) allocated 75MHz of spectrum in the 5.9GHz band for DSRC used in the Intelligent Transportation services to improve highway safety and efficiency as a part of national ITS program. Also, in Europe in August 2008 the European Telecommunications Standards Institute (ETSI) has allocated 30 MHz of spectrum in the 5.9GHz band for ITS.

2. Vehicle-to-Infrastructure

In Vehicle-to-Infrastructure (V2I) section, communications are performed between vehicles (OBEs) and infrastructures (RSEs). In the following, the applications, equipment and pilot are explained.

2.1 Applications

Application #1: Electronic Toll Collection. Automatic toll payment based on variable tariff depending to travel time or based on travelling length.
Application #2: Emergency Vehicle Prioritization. Upon approaching an emergency vehicle to a predetermined intersection, the traffic light turns green to clear that route while the emergency vehicle passes and then turns it to the normal condition.
Application #3: Traffic Data Collection. Collecting traffic data from urban and interstate roads through vehicle OBEs and transmitting them to the RSEs
Application #4: Sidetrack to Main Road Warning. Before reaching to an intersection, by transmitting the presence and speed of vehicles on a sidetrack, a safe intersection will be provided preventing collision between approaching vehicles
Application #5: Informing Road Traffic Situation in the Points out of Drivers Sight. A vehicle equipped with an OBE system can be aware of traffic condition at the out of driver's sight locations by receiving information from the OBE device of front vehicles.
Application #6: Traffic Restrictions and Weather Information. [2].

2.2 Communication and Power Supply Equipment

In this section, we describe communication equipment and power supplies used in the project. Inasmuch there is no widespread and ready-to-use fiber optic network, in the pilot stage of the project, we restored to cellular communication of mobile operator networks (as shown in Fig. 2) for establishing the connection between the deployed RSEs and the CCR in order to collect their data. Fig. 2 shows the IP network of the CVT project. As it has been depicted, there is a secondary network as a backup for the primary one.

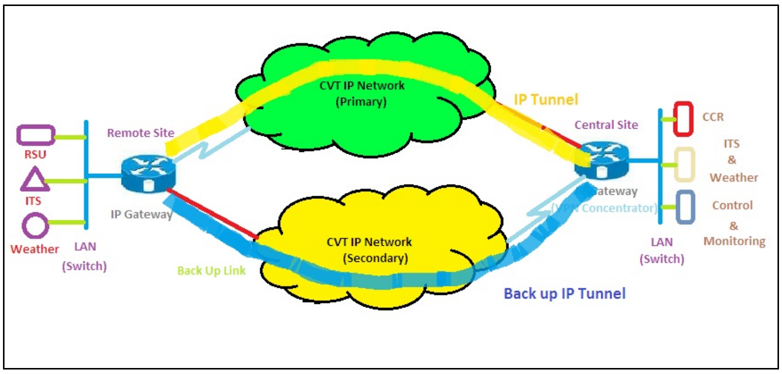

Figure2. A schematic of IP network of CVT project

There are several mobile operators in Iran which provide 2G and 3G technologies. We were required to select the communication equipment in a way that while connecting to the existing technologies, to be able to adapt to the future technologies. Thus, technical team of the project evaluated plenty of equipment available in the world market which at last 4 of them were chosen to be used. It is worthwhile to mention that some of the criteria in selection process include supporting 2G and 3G mobile network such as GSM, GPRS, Edge, supporting two SIM cards for redundant communication with different operators, capable of connecting to both Indoor and Outdoor antenna and supporting IP protocol.

One of the challenges of the project was to provide electrical power for road side equipment. Among the possible solutions, solar power is used as an efficient and promising solution. Fig. 3 demonstrates the power supply system of the RSEs.

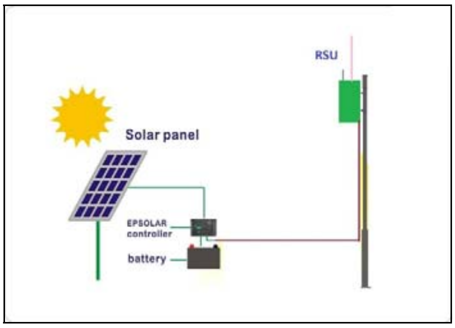

Figure3. Solar power generation system of equipment

2.3 RSEs Deployment

In order to locate the RSEs alongside of the pilot roadway there are some deciding criteria as follows:

- Availability of communications infrastructure for transmitting the received data from RSEs
- Physical security of the location regarding the equipment
- Availability of power supply

- Ease of set-up and maintenance
- Availability of toll-collecting, weather and ITS equipment

Considering the mentioned factors, the expert panel of the project commenced to find the best locations. Thus, after several inspections of the pilot roadway and also negotiation with local authorizes, initial locations were proposed. All of the deployed RSEs alongside of the roadway execute application #3. However, depending on the location of the RSEs, they perform another V2I application as well. The rule is no more than two applications should be run on an RSE. Fig. 4 shows the pilot roadway wherein locations of the RSEs and their corresponding application have depicted. Although the specified application(s) (depending on the location) have been assigned for the RSEs, they can be changed whenever it is required.

Figure4. Roadway of V2I pilot: RSEs and applications

2.4 Vehicle-to-Infrastructure Pilot

Pilot of V2I sub-project was carried out by utilizing 300 vehicles in two phases. At the first phase, OBE devices were set up on 120 public transportation vehicles including buses and heavy trucks. While performing their regular driving activities, these vehicles were experiencing V2I applications. Second stage of the pilot has been carried out locally over 180 vehicles in collaboration with stakeholder’s cooperation for some special functionalities such as updating VMS panels allowing significant improvement in the usefulness of displayed messages as a result of more detailed real-time and vehicle-specific information.

2.5 VMS Panels Updating Application

VMS panel updating application, as an effective mechanism for displaying operational applications of connected vehicle technology, has been included in the program of the CVT project executive board since January 2013. In order to observer the outcome of this application, we require to equip just some sort of vehicles such as road maintenance patrols or road police vehicles to OBE devices. By setting up the OBE in a road maintenance patrol or a road police vehicle, the agents within these vehicles, based on current traffic situation, can specify required warning messages while they travel on the road and then issue them toward the VMS panel. More details and results are available on the project website [5].

3. Vehicle-to-Vehicle

Vehicle-to-Vehicle (V2V) communications are between OBE devices within the vehicles. However, without loss of generality, in collision warning notification (application #9) information are also received by an RSE in order to be transmitted to the control center. V2V applications are safety based.

3.1 Applications

Application #7: Sudden Braking Warning. Sudden braking of a vehicle will be informed quickly to the behind drivers via its OBE to prevent a chain collision [3].

Application #8: Emergency Vehicle Passing Warning. The vehicles are informed that an emergency vehicle is passing and then they are expected to change their path accordingly [4].

Application #9: Collision Warning Notification: The OBE of crashed vehicle transmits alarm messages to behind vehicles aiming at warning them about the incident and therefore reducing the probability of further damages caused by the accident.

3.2 Vehicle-to-Vehicle Pilot

In V2V pilot, 7 vehicles were utilized for application #7, #8 and #9**.** Through several scenarios, the performance and accuracy of the applications were tested. In the following, we describe the scenarios.

Scenario 1: Application #7, Sudden Braking Warning. At the beginning, the vehicles would place in positions like shown in the Fig. 5. When a vehicle brakes hard, it broadcasts a warning message. In this scenario, only the vehicles shown in section 1, which are vehicles 1, 2 and 3, show the message on their screens to inform the drivers.

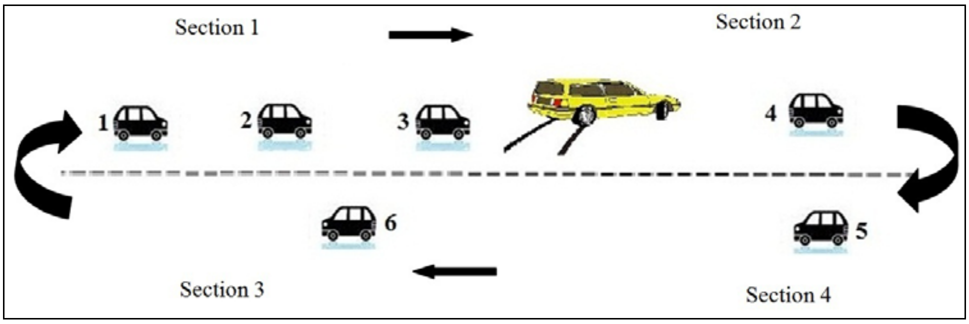

Figure5. Pilot scenario of application #7

Scenario 2: Application #8, Emergency Vehicle Passing Warning. At the beginning, the vehicles would place in positions like shown in the Fig. 6. Then, the emergency vehicle as travels on the shown path warns the front vehicles about its existence. In other words, in each section, only the vehicles which are in front of the emergency vehicle show the warning message to the drivers.

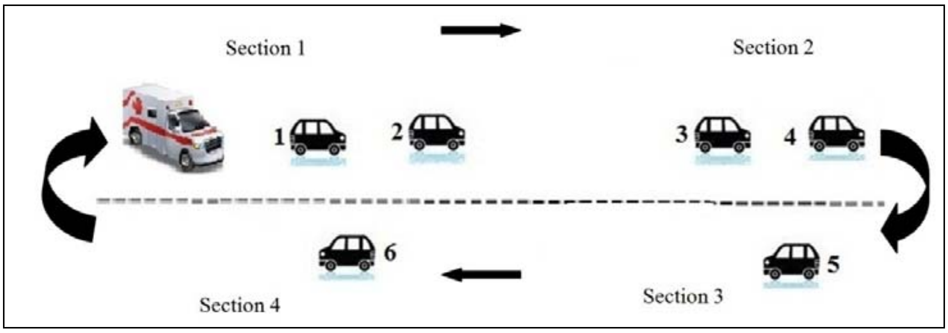

Figure6. Pilot scenario of application #8

Scenario 3: Application #9, Collision Warning Notification. At the beginning, the vehicles would place in positions like shown in the Fig. 7. When the crashed vehicle crashes, it stops and broadcasts the warning message. In this scenario, the vehicles shown in section 1, which are vehicles 1, 2 and 3, show the message in their screen to the drivers. Also, in this application, the accident is reported through a deployed RSE to the Central Control Room (CCR). Indeed, OBEs, which are at the transmission of the RSE, transmit the collision message to RSE which then transmit the message through the established internet connection to the CCR. In this application, the collision message is transferred hop-by-bop to the vehicles by a multihop algorithm.

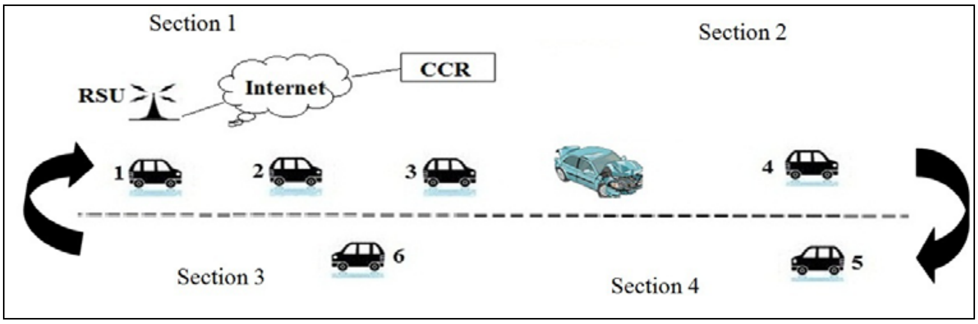

Figure7. Pilot scenario of application #9

4. Central Control Room (CCR)

Central Control Room has been designed in the CVT project to control and monitor all RSE equipment. The establishment of CCR has both management and technical aspects. In the management aspect, there are short-term (during the project) and long-term (operational deployment of the system) perspectives. In long-term, this center is used by principal stakeholders along with other ITS systems.

From the technical aspect, through the provided processing and communication infrastructure, the CCR perform the following.

- Collecting the harvested data of RSEs and then making report based on these data
- Monitoring the mechanism of RSE equipment
- Receiving the road weather information and also broadcasting the messages for application #6.
- Different levels of user authentication for accessing the resources and information.

Technical aspect of CCR consists of three sections: processing equipment, communication equipment and monitoring software. An interesting point of CCR is 24/7 working time of its hardware equipment. All in all, 5 months has been considered for pilot and data harvesting which requires the equipment work uninterrupted during this period. Thus, an advanced configuration was selected for the server. In this regard, a Rack server with capacity of 24U and 2 air fans was assembled. Also, the CCR should be equipped with a remote communication facility in order to connect to the RSEs and IRIMO (I.R. of Iran Metrological Organization) server. Hence, two considerations should be given to the selected remote communication technology: type of technology which connects RSEs to the CCR and type of technology proposed by IRIMO for receiving metrological data. For connection between RSEs and the CCR there are limited choices. Since the equipment should be deployed out of urban areas, ordinary technologies like ADSL, MPLS, fiber optic and Point-to-Point cannot be used. Therefore, GPRS and 3G as ubiquitous technologies were selected for this task. Also, the connection between the CCR and IRIMO server is carried out through a FTP connection to rwis.irimo.ir. The designed program at the CCR side periodically fetches the information from the IRIMO server.

Third component of CCR is control and monitoring software. Regarding the design of this software, MVC (Model, View and Controller) architecture has been utilized which is a popular three layered design. The software was programmed by PHP 5 and MySQL 5 under Linux CentOS distribution and Apache server. Fig. 8 shows a view of GUI of the software representing the Traffic Data Collection application. In this figure, the information recorded by the CVT system showing a bus crossing an RSE (code TEH-KRJ-1-367)which is installed at Tehran-Karaj highway . The information shows speed and direction of the bus when it had reached the RSE.

پلاک خودرو	نام RSU	سرعت	طول جغرافیایی	عرض جغرافیایی	جهت	فاصله (کیلومتر)	زمان
33 253 ع 93							پالایش
33 253 ع 93	TEH-KRJ-1-367	87	51.246319224753	35.715094976362	1	1.0158348203501	09:22:46 2013-07-28
33 253 ع 93	TEH-KRJ-1-367	91	51.214749250241	35.719105680928	2	1.8751086543386	20:10:09 2013-07-27
33 253 ع 93	TEH-KRJ-1-367	90	51.247866210799	35.714865793244	1	1.1575567100108	09:23:53 2013-07-27
33 253 ع 93	TEH-KRJ-1-367	53	51.213431447312	35.719334864046	2	1.9961602112301	20:26:30 2013-07-26
33 253 ع 93	امیرکبیر-کاج	82	51.240016689006	35.759384613925	2	6612.4359443198	09:19:19 2013-07-26
33 253 ع 93	TEH-KRJ-1-367	50	51.213546038871	35.719334864046	2	1.98588204143	20:08:56 2013-07-25
33 253 ع 93	TEH-KRJ-1-367	98	51.247350548784	35.714923089023	1	1.1108124579987	09:21:54 2013-07-25

Figure8. A view of GUI of the CCR: Recoding the information of the bus crossing a RSE mounted over a VMS panel at the beginning of Tehran-Karaj highway

5. Conclusion

Through conducting the pilot stage of the CVT project in I.R.IRAN, the required conditions has been achieved to aware all stakeholders about applications of connected vehicle technology in different fields. In this regard and according to the outcome of similar projects around the world, initial preparations have been arranged in order to develop this technology in various sections like automobile manufacturing industry or in economic sections like insurance industry. By means of the project interactions and also its notifications, the authorities have been noted that the future of transportation depends on the connected vehicle technology. As a result, some of the stakeholders have commenced to define their specific applications to meet their own needs. We can refer to the administrators of urban traffic control management, road transportation managers and also private organizations in freight and passenger transportation as pioneer stakeholders who are determined in operational usage of this technology. Therefore, by the end of the pilot at March 2014, some of the applications of vehicle technology like VMS panels updating, electronic toll payment for buses and heavy vehicles on the highways, behavior control and green driving education of rural drivers, fuel consumption reduction via vehicle inspection messages issued toward the drivers and emergency vehicle prioritization in urban intersections will be exploited operationally.

Acknowledgment

Deployment of this project has been possible after approving by research council of the Ministry of Science, Researches and Technology (MSRT) and sponsoring by Industrial Development and Renovation Organization of Iran (IDRO). Hereby, we extend our thanks to all organizations and people who have contributed in the development of the project specially representatives of stakeholders.

References

We took advantage of many resources and reference in this project which indexing them all here is not applicable. Hence, we just suffice to some links of the project website through which supplementary and useful information is accessible.

[1] General introduction to the project:
http://cvt-project.ir/En/EnInfoGrid.aspx?SubjectType=73
[2] The link of application #6:
http://cvt-project.ir/En/EnNewsDetail.aspx?SubjectType=109&InfoID=1172
[3] The link of application #7:
http://cvt-project.ir/En/EnNewsDetail.aspx?SubjectType=109&InfoID=1154
[4] The link of application #8:
http://cvt-project.ir/En/EnNewsDetail.aspx?SubjectType=109&InfoID=1144
[5] The link of VMS panels updating application:
http://cvt-project.ir/En/EnNewsDetail.aspx?SubjectType=109&InfoID=1212

Appendix- Selected pictures from the CVT pilot project


Figure A.1. RSE deployment


Figure A.2. OBE installed on volunteer buses

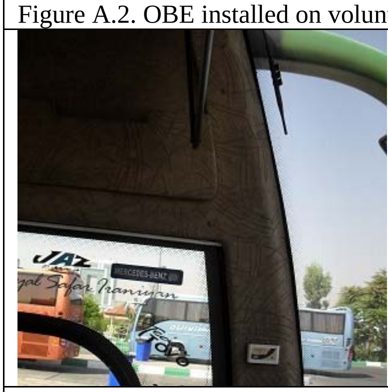

Figure A.3. GPS & DSRC antenna inside a bus

Figure A.4. In-vehicle display

Figure A.5. In-vehicle equipment of application #2

Figure A.6. Installing OBE in vehicle trunk