2011 Third International Conference on Computational Intelligence, Communication Systems and Networks

A Survey of Intelligent Transportation Systems

Sheng-hai An
School of Information Communication Engineering
SungKyunKwan University
Suwon, Korea
shenghai85@skku.edu

Byung-Hyug Lee
School of Information Communication Engineering
SungKyunKwan University
Suwon, Korea
pstmind@skku.edu

Dong-Ryeol Shin
School of Information Communication Engineering
SungKyunKwan University
Suwon, Korea
drshin@skku.edu

***Abstract*—With the rapid increase of modern economical and technical development, the Intelligent Transportation System (ITS) becomes more and more important and essential for a country. Practice shows that relying only on the construction of transport infrastructure and expansion does not fundamentally solve the existing transportation problems and sometimes it even makes such problems more severe. So every country is actively exploring ITS technology to solve traffic problems. But due to the different situations of the fund investment, current technology merit and the various traffic problems for each country, the development level of ITS and research areas are distinct. This paper focuses on the comparison and analysis of international ITS research and integrates the ITS technologies to design an integration model. We regard the traffic problem as not only a problem for individual countries, but also a global topic. Countries should improve the technology communication, update and enhance ITS techniques.**

Keywords-component; Intelligent transportation system(ITS), ITS techonolgy, communication;

I. INTRODUCTION

Intelligent Transportation System (ITS) is based on the increasing demands of the transportation development. It integrates information, communications, computers and other technologies and applies them in the field of transportation to build an integrated system of people, roads and vehicles by utilizing advanced data communication technologies. It can establish a large, full-functioning, real-time, accurate and efficient transportation management system. ITS makes service objects' focus change from road managers to road users. In order to achieve this purpose, ITS uses advanced technology to provide drivers with the road information and convenient services to reduce traffic congestion and to increase road capacity.

The previous concept of Intelligent Transportation System (ITS) was proposed by United States in the 20th century 60 years. Currently, the research and development bases have been established in the United States, Japan and European Union in the worldwide range. In addition, South Korea and Singapore also have high level of ITS development.

The rest of this article is organized as follows: Section II presents the development of ITS technologies, country's ITS projects and research areas in United States, Japan, the European Union and South Korea respectively. Section III describes many key underlying technologies for ITS. Section IV compares and analyzes the development of ITS technologies in those countries, and integrates the comparison and analysis to design an integration model which we think is more useful. Section V concludes this paper.

II. THE DEVELOPMENT OF ITS IN VARIOUS COUNTRIES

As a basis for traditional traffic engineering, Intelligent Transportation System (ITS) developed a new transport system. Because of various national circumstances, development priorities are different and the contents of the ITS research are also not the same.

Generally, ITS is recognized as using information, communication, control, computer technology and other current technologies to establish a real-time, accurate and efficient transportation management system.

A. United States

In the United States, Electronic Route Guidance System (EGRS) was the initial stage of Intelligent Transportation system (ITS) in 1970s. In 1991s United States' congress enacted integrated surface transportation efficiency programs (ISTEA). TEA-21 (Transportation Equity Act for the 21st Century) as a successor project ISTEA was formulated in 1997s. Compared with ISTEA, TEA-21's project scale and economic investment have a significant growth which can provide a strong guarantee for the development of ITS technology.

In order to improve the safety and efficiency of the nation's road transportation system, Federal and state departments of transportation (DOTs) cooperated with vehicle manufacturers to propose the Vehicle Infrastructure Integration (VII) based on the evaluation of the technical, economical, and political feasibility of deploying a communications system. The VII provides a communications link between vehicles on the road (via On-Board Equipment, OBE), and also between vehicles and the roadside infrastructure (via Roadside Equipment, RSE) [1]. The VII's key technology is emphasized on short range communication (DSRC) which is allocated by FCC, and spans over 75 MHz of spectrum in the 5.9 GHz band in US. VII connects vehicles and infrastructure and creates an "enabling communication infrastructure". But there are two base premises that all new vehicles would be equipped with DSRC at 5.9GHz and GPS and a nationwide roadway-based

978-0-7695-4482-3/11 $26.00 © 2011 IEEE
DOI 10.1109/CICSyN.2011.76

communications network should be created. Fig. 1 [2] shows the Architecture of VII.

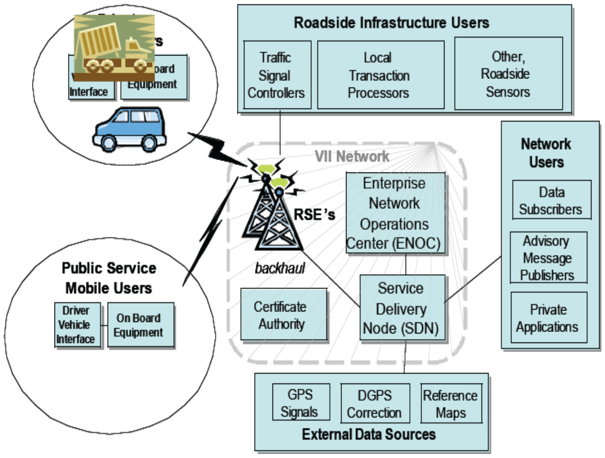

Figure 1: Vehicle Infrastructure Integration Architecture

The ITS Strategic Research Plan, 2010-2014, was promulgated by the United States Department of Transportation (USDOT) on December 8, 2009. This plan defines the strategic direction for the USDOT's ITS research program for the next five years. The ITS Strategic Research Plan is designed to achieve a vision of a national, multi-modal surface transportation system which features a connected transportation environment among vehicles, the infrastructure and passengers' portable devices. This connected environment will leverage technology to maximize safety, mobility and environmental performance [3].

B. Japan

Because of Japanese government's massive investment on ITS, they have got impressive benefits from applying those technologies into the operational deployment. And the maturity of those applications enables Japan to play a leading role in the world in intelligent transportation systems.

To collect and transmit real-time traffic information, Japan began their research in 1996 and created the world's first vehicle information communications system (VICS) which has been available in nationwide since 2003.

But since 2003, traffic and congestion information in Japan has been generated increasingly through the use of probe vehicles, specifically by making VICS-enabled vehicles the probe vehicles themselves [4].

The technical architecture of Japan's VICS (Fig. 2 [4]) which was designed in the early 1990s was called "Version 1.0" of in-car navigation systems in Japan. Japan is developing the Smartway now, which might be called "Version 2.0" of the country's state-of-the-art ITS service [4]. Smartway finished its concept development in 2004 and was put into partial deployment in 2007. This process only took 3 years. It is an extremely fast development timeline.

Japan began widespread national Smartway deployment in 2010[4].

Figure 2: Japan's Vehicle Information Communications System (VICS)

Figure 3: Overall Picture of Smartway

Smartway cooperated with vehicle-highway was developed on the basis of Japan's deployment of ITS experience. As showing the overall of Smartway in Fig. 3 [5], there are a lot of services which are provided by using a platform. Using 5.8 GHz DSRC technology, Smartway can provide visual information of road conditions ahead, traffic information through audio in a visual format and location, and contextually specific information to the driver. Smartway is able to warn drivers when they are coming across particularly accident prone areas of a roadway, and uses a DSRC-enabled roadside unit to alert drivers on the main lanes of the presence of merging vehicles and sends appropriate warnings.

C. European Union

In order to control and solve the traffic problems, in 1980s, United Kingdom, France and Germany as the representatives of European countries, began to seriously study ITS technology. In 1985s, EUREKA (European Road Transport Telemetric Implementation Coordination Organization) was established to promote the cooperation of government and private organization in research and development of ITS. In the following year, PROMETHEUS (Programme for European Traffic with Highest Efficiency and Unprecedented Safety) was launched. But the program started officially in 1987s with a period of 7 years. DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe) as the second phase of Europe's R & D part of the framework was adopted in June 1988s.

In 1991s, because the DRIVE program was implemented successfully, the EU set up ERTICO. ERTICO is non-profit cooperative organization in Europe which is established based on the cooperation between government and private enterprises.

In 1994s, when PROMETHEUS (Programme for European Traffic with Highest Efficiency and Unprecedented Safety) went into the end of the period, after consultation, all members of the unit agreed to establish a new round of research project PROMOTE. This plan involved much broader problems of integrated transport systems. The plan did not just focus on the vehicle systems, but also was applicable to public sector and was no longer limited to enterprise-wide.

In recent years, ERTICO technology uses CVIS (Cooperative Vehicle Infrastructure Systems) (Fig. 4 [6]), COOPERS (Cooperative Systems for Intelligent Road Safety) (Fig. 5 [7]) and the other wireless communication systems mean to implement the exchange of information between road infrastructure and vehicles, vehicles and vehicles so that it can improve traffic safety and efficiency with the latest ITS services which is being developed.

In order to begin, develop and test the technologies which could make cars be able to communicate with each other and know the nearby roadside infrastructure. CVIS (Cooperative Vehicle-Infrastructure Systems), a major new European research and development project was proposed [8].

Cooperative ITS is developed on the basis of (Fig. 6 [9]) many communication-paths communications. Focusing on the last group and I2V communication systems, the European Integrated project COOPERS (Cooperative Systems for Intelligent Road Safety) plans to connect vehicles on the motorway to the road infrastructure via continuous bidirectional wireless communication [9] (see Fig. 7 [7]).

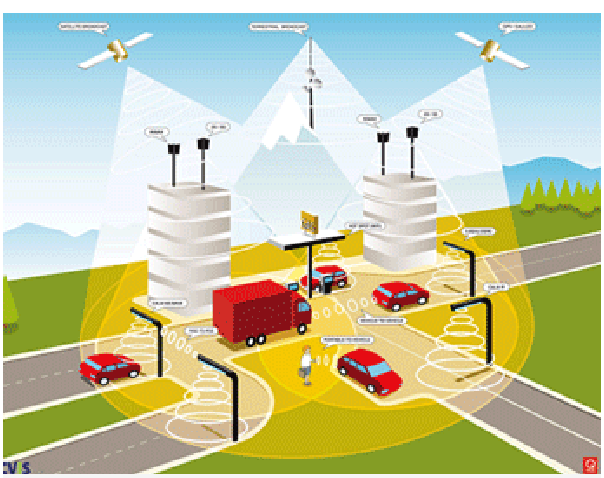

Figure 4: IT CVIS

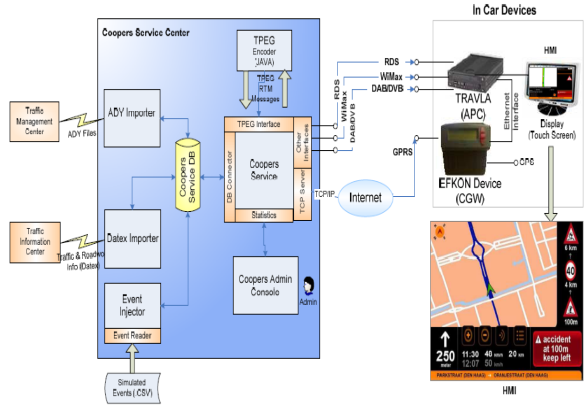

Figure 5: The overall COOPERS system layout

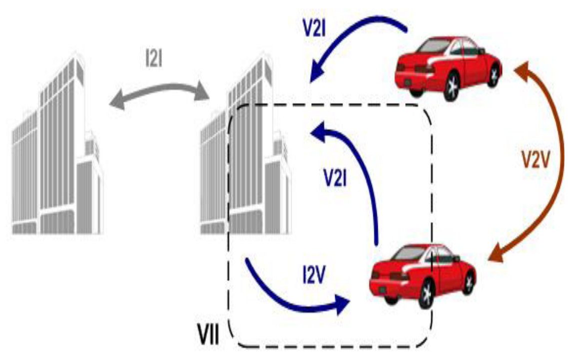

Figure 6: Communication-paths in cooperative ITS

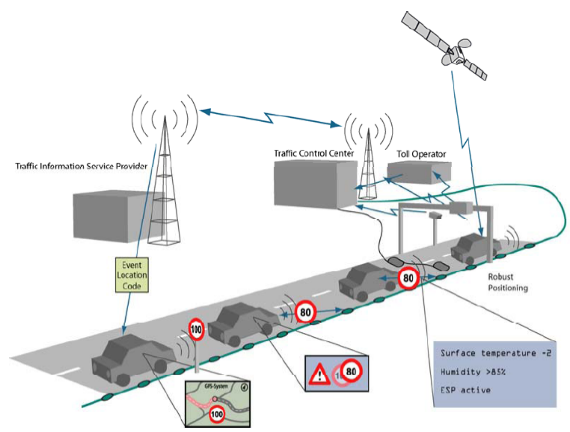

Figure 7: COOPERS vision of continuous bidirectional I2V communication along motorways

D. *South Korea*

South Korea's strengths in several ITS application areas make it a world leader in intelligent transportation systems.

South Korea formulated the "transportation system efficiency Law", which set a national legal basis for ITS implementation plan, and promoted the work of ITS technical standards in February 1999.

In December 2000, South Korea ventilated a 20-year blueprint for ITS development which used to be called

National ITS Master Plan for the 21st century. Seven specific ITS application areas which are part of a National ITS Service (Fig. 8 [6]), along with time schedules and budgets were proposed as a strategic guideline for development by the plan.

Figure 8: National ITS Service

The ITS Master Plan defined three phases of ITS development in Korea: the first is from 2001 to 2005, the main task is to compose ITS institutions and make the initial work on ITS; the second phase is from 2006 to 2010, this stage is the formation of industrialization, expanding the scale of Stage; the third stage is from 2011 to 2020, this phase is to ensure the system type connection, compatibility and efficiency of operation and to plan more advanced technology systems for the advanced stage.

A central mission of the National ITS Service is to create a network of traffic systems which can facilitate interactions and interconnection between South Korea's large cities.

Now South Korea has basically completed the basic framework of the ITS, technology standardization, electronic road maps and DB (data) in the establishment.

III. Key Underlying Technologies

In this Section, we describe many key underlying technologies for ITS technologies, such as Global positioning System (GPS), Dedicated-Short Range Communications (DSRC), Wireless networks, Mobile Telephony, Radiowave or Infraed Beacons, Roadside Camera Recognition and probe Vehicles or Devices.

A. Global positioning System(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. Countries like Holland and Germany are using OBUs equipped with satellite-based GPS devices to record miles traveled by automobiles and trucks so as to finance their transportation systems [4].

B. Dedicated-Short Range Communications(DSRC)

Dedicated-Short Range Communications (DSRC) is one-way or two–way wireless communication channel that operates in the 5.8 or 5.9 GHz wireless spectrum and are specifically designed for automotive uses. DSRC is capable in two-way wireless communications between the vehicle and roadside equipment. It plays a main part in many intelligent transportation systems including vehicle-to-infrastructure integration, vehicle-to-vehicle communication, adaptive traffic signal timing, electronic toll collection, congestion charging, electronic road pricing, information provision, etc. DSRC is a subset of radio frequency identification (RFID) technology [4]. The technology for ITS applications works on the 5.9GHz band in United States and the 5.8GHz band in Japan and Europe. Nowadays, DSRC systems in Europe, Japan and the United States are generally not compatible. In 2004, the U.S. Federal Communications Commission (FCC), prescribed a common standard for the DSRC band both to promote interoperability and to discourage the limitation of competition through proprietary technologies [4].

C. Wireless networks

Wireless networks are accessible to rapid communications between vehicles and the roadside which is similar to technology commonly used for wireless Internet access, however it have a range of only a few hundred meters. Nevertheless, this range can be extended to pass information onto the next vehicle or node by each successive vehicle or roadside node. WiBro is increasingly in usage in South Korea, based on WiMAX technology, as the wireless communications infrastructure to transmit traffic and public transit information throughout its transportation network [4].

D. Mobile Telephony

Standard third or fourth generation (3G or 4G) mobile telephone networks can be used to transmit information in the applications of ITS. There are advantages of mobile networks like wide availability in towns and along major roads. Additional network capacity may be required if vehicles are fitted with mobile networks, and network operators might need to cover these costs. However, mobile telephony may not be suitable for some safety-critical ITS applications since it may be too slow [4].

E. Radiowave or Infraed Beacons

Vehicle Information Communications System (VICS) from Japan uses radio wave beacons on expressways and infrared beacons on main roads to transmit real-time traffic information. VICS uses 5.8GHz DSRC wireless technology (Arterial roadways are moderate capacity roadways just below highways in level of service with a key distinction that arterial roadways tending to use traffic signals. Arterial roadways carry large volumes of traffic between areas in urban centers.) [4].

F. *Roadside Camera Recognition*

Camera or tag-based schemes can be used for zone-based congestion charging systems (as in London), as well as for charging on specific roads. Cameras placed on roadways are used where drivers enter and exit congestion zones in such systems. The cameras utilize Automatic License Plate Recognition (ALPR) to identify vehicle license plates which is based on Optical Character Recognition (OCR) technology;

The back-office servers assess and post charges to drivers for their use of roadways within the congestion zone. Moreover, it is able to pass the information digitally [4].

G. *Probe Vehicles or Devices*

The so-called “probe vehicles” (often taxis or government-owned vehicles equipped with DSRC or other wireless technology) is deployed by several countries. This equipment covers the speed and location of vehicles to a central traffic operations management center, where probe data is assembled to generate an area-wide picture of traffic flow and to evaluate congested locations. Extensive research has also been conducted to use mobile phones that drivers often carry as a mechanism to generate real-time traffic information, using the GPS-derived location of the phone as it moves along with the vehicle. For example, in Beijing, more than 10,000 taxis and commercial vehicles have been equipped with GPS chips that send travel speed information to a satellite, which then sends the information down to the Beijing Transportation Information Center and then the data are translated into average travel speeds on every road in the city [4].

IV. AN INTEGRATE MODEL

A. *Intelligent new vehicle*

We equip the new vehicle not only with DSRC and GPS but also with distance sensor. We set four distance sensors into in the bottom front, back, left and right of vehicles (see Fig. 9).

The distance of length and width is fixed when the distance sensors are equipped. And we store the distance information into vehicle services. If accident happens to the intelligent vehicle, the distance between two sensors will be changed. The vehicle services will calculate the two sensors’ current distance. According to the distance, the vehicle services will connect to control center, send recent road information and provide the crash information. If the distance between two sensors is shorter than limited, vehicle services will not only connect to control center but also connect to hospital center and send the location of crash.

The Service will calculate the length from the vehicle’s sensor which is in the bottom of front to another vehicle’s bottom of back sensor (Fig. 10). If the distance is shorter than limited, vehicle services will warn the driver that the distance between vehicles is too close.

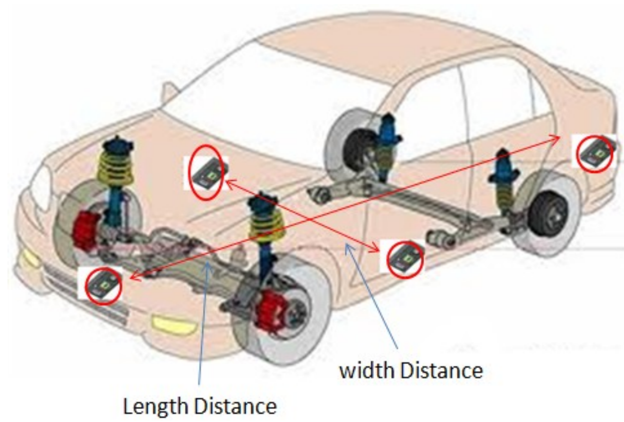

Figure 9: The position of distance sensors

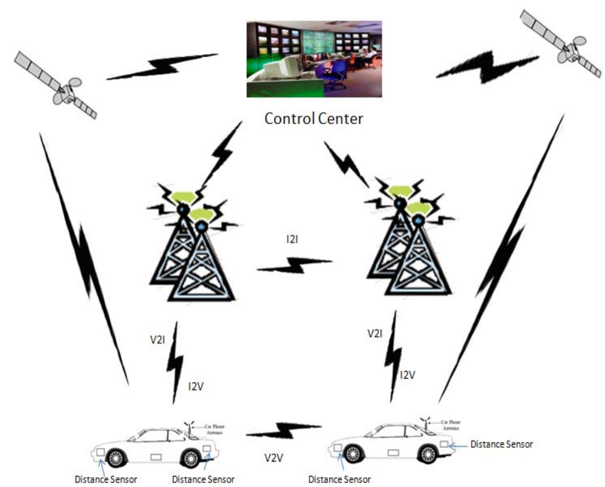

Figure 10: Communication between two intelligent new vehicle

B. *An Integrate Model*

With comparison and analysis ITS research, we find that there are many technologies needed to integrate together. We integrate those technologies and design an integrated model (See Fig. 11). If the integrated model system comes true, it is believed that most of current transportation problems can be solved. Smartway 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 Smartway 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 Smartway, United States’ VII, European Union’s CVIS, COOPERS is a more useful, safe, efficient ITS transportation model.

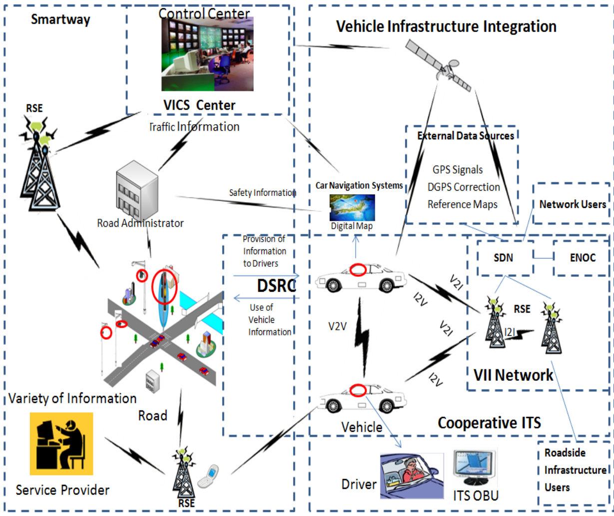

Figure 11: An Integrate ITS Model

V. CONCLUSION

Due to the different situations of the fund investment, current technology merit and the various traffic problems for each country, the development level of ITS and research areas are distinct. We regard the traffic problems as not only problems of individual countries, but also a global topic. Because the Model integrates the advantages of many countries' ITS technologies, it must be more useful, safer and more efficient than those models which use those ITS technologies respectively. As a result, improving the technology communication among countries, updating and perfecting ITS techniques will be the fastest as well as most efficient method to solve current traffic matter.

ACKNOWLEDGMENT

This research was supported by a grant (I09100210) from Gyeonggi-do International Collaborative Research Program.

REFERENCES

[1] Michele Weigle, "Vehicle Infrastructure Integration," 2008, CA 795-895

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] Reasarch and Innovative Technology Adminstration(RITA), "ITS Strategic Plan Overview", The URL for ITS Strategic Plan Overview is http://www.its.dot.gov/research_planning.htm.

[4] Setphen Ezell, "Intelligent Transportation Systems," January 2010.

[5] Hiroshi MAKINO, Japan, "Smartway Project".

[6] ITS Korea, "About ITS Europea", The URL for ITS Korea is http://www.itskorea.or.kr/its/overseas1.jsp.

[7] Martin Bohm, Susanne Fuchs and Reinhard Pfliegl, "Driver Behavior and User Acceptance of Cooperative Systems based on Infrastructure-to-Vehicle Communication," Donau-City-Strasse 1, A-1220 Vienna, Austria, August 2008.

[8] Lina Konstantinopoulou, "Cooperative Vehicle-Infrastructure Systems," August, 2010.

[9] Bobby J.W. Nijssen, "Cooperative Intelligent Transportation Systems," February 12, 2008.