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Involving Mobile and Motorized Society Advanced by Wireless Technologies for Safety Driving

— Technology Innovation Leads to Global Niche Business —

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Abstract

A safety driving support application is one of the development goals in the Intelligent Transport Systems (ITS). For its realization, Dedicated Short Range Communications (DSRC) typed Inter-Vehicle Communications (IVC) is now under study. In this paper, it is clarified that the priority development target in the mobile and motorized society is the DSRC typed IVC systems and the technical innovation in its elemental technologies developments makes the global niche business possible.

1. Introduction

Recently, Japan is regarded as a test-bed of high technologies because a lot of first products in the world are existed and usually used in our ordinary life. Mobile phones and cars become very essential and popular tools for "communication" and "movement". Especially in the usage of the high-end users, they include not only the inherent functions of the "communication" and the "movement" but also the high level additional functions that utilize the advanced technologies based on IT (Information Technology) for the information providing services. It is important for the success in the information and telecommunication business to promote the high-tech products for the high-end users, firstly. A product of good reputation will be expanded to the general users. The researchers of the leading edge technologies in every manufacturing company should have the ability to deal sensitively with user needs.

The subsistence of a manufacturing company depends on not mere products but profitable goods which should be continuously produced to the conventional or new market. Even if the hit goods contribute the profit for today's business at the present time, they certainly have a life-time with the reason that the consumers will easily be tired of them and want to get another new goods fashionably. Therefore, the mission of the researchers shifts from just a technology-oriented "research for research" to a customer-oriented "compatibil-

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ity between profit and creation", considering consumer's needs and providing them with the technical seeds. In terms of the profit, it is important to make a business strategy plan and operate it in order to have an advantage over competitors. At the viewpoint of the product strategy, the No.1 and the only one product steers the company to the domination of the business. Moreover, for the purpose of recovering the initial investment for the expenses of the present development and getting a profit in future, a financial plan should be prepared considering the life-time of the product. Therefore, the project leaders of the development of a new product are expected to have not only basic knowledge about marketing, accounting and finance but also the high performance to offer a product matched with customer's needs, constructing a value chain between research, development, production and sales in the company, immediately.

On the other hand, at the viewpoint of the creation, the "technical core competence" that become a continuous source of competition against other companies should be strengthen by the combination of the wisdom of the researchers and the various regions of technologies. Furthermore, the cooperation with outside research institutes, such as universities and other companies, is effective to develop the product speedily. Of course, it is important to get the strength points of own technologies but it is not necessary to make up everything with them.

However, the number of the high-tech researchers in companies is decreasing through the job displacement and the external assignment of each company because of the present economic recession from 1990's, so-called the "Heisei recession". Existing researchers should have a mind to challenge new developments consistently no matter how different technical region based on their current technical skills. The key of the success of a business is that each of them has a "will" which never give up until their present technical development would certainly become useful for the progress of our society in addition to the expansion of their company's business in future. They should enjoy their job for the purpose of the realization of their dreams as an engineer even if there will not be enough number of researchers.

Nikkei Stock Average in the Tokyo Stock Exchange hit the highest record 38,915 Yen in December 1989 of 15 years ago. And after two years, in December 1991, what we call the economic "Bubble Burst" happened. The Research and Development (R&D) of the new mobile telecommunication technology was already started at that time. It produced the 3rd generation mobile phone system such as W-CDMA, CDMA2000 and so on, which has now spread throughout the world. I was one of young researchers struggling with the R&D of those systems. The new concept of the 3rd generation mobile phone system was "various multimedia information" provision to the users in addition to the "anytime, anywhere, anyone" communications which was already realized by the 2nd generation mobile phone system. My intellectual curiosity was excited to perform the development with the sympathy to the new concept.

In this paper, the needs of the technology development in the modern mobile and motorized society are firstly described. Secondly, the road map of the technology developments considering the needs is presented and its core competence is clarified. Finally, the possibility of the global niche business is mentioned.

2. Needs of Technology Developments in Mobile and Motorized Society

2.1. What are mobiller needs?

The mobile phone and the vehicle are now essential goods in our everyday life scene. The mobile phone is much more convenient than wired land phone in terms of talking to anytime, anywhere, anyone. In November 2004, the number of mobile phone users in Japan is about 85 million, of which that of IP connection service users is over 73 million, therefore two third of Japanese are mobile Internet users so called "Mobillers". We easily use our mobile phone utilizing basic data services, for example, Internet access and E-mail in addition to voice call service. Users of broadband data communication services such as image and movie, which mainly entertain us, are recently rapidly increasing. On the other hand, the vehicle is also useful in terms of going anytime, anywhere. In August 2004, the number of automobiles in Japan is 77 million and that of those passing the express ways is more than 4.1 million per a day. In addition, that of the car navigation systems is more than 15 million. They enable the drivers to go to their destination from anywhere without losing their way avoiding the traffic jam. Reflecting above the mentioned social environment, the development of the Intelligent Transport Systems (ITS) is presently expected to match the needs of both the drivers and the passengers. Considering that they are regarded as one of the mobillers, one of their needs is the improvement of "convenience" and "amusement" during their driving. Moreover, the drivers' interest is currently focusing on the safety arrival to the destination without the traffic jam. Therefore, the improvement of "comfort" and "safety" during their driving becomes more important matter.

2.2. Telematics Services

Telematics services are recently started in order to provide the drivers and the passengers with their required information by using the car navigation system connected with the mobile phone. In the newest telematics service, it is possible to get various information through Internet by IP connection service, such as wide-area road traffic information, sending or receiving E-mail, online shopping and amusement information for passengers, as well as hands-free by the mobile phone and simple telephone services utilizing speech recognition. It is also possible to establish the SOS emergency call and trace the stolen vehicles automatically by utilizing the information linked to their vehicle's position obtained from the GPS (Global Positioning System) which is the basic function of the car navigation system.

2.3. ETC and VICS

Although the telematics service provides the drivers and the passengers with "convenience", "amusement" and "comfort", it does not lead to the explosive growth at this time. The reason will be clarified by the comparison of the spread speed of the Electronic Toll Collection (ETC) system with that of the Vehicle Information and Communication System (VICS). The ETC system, which started its service at 685 tolls with the aim of the traffic jam reduction around the toll collection points on the express ways in November 2001, is installed in all tolls (about 1300) across the country, and the number of its on-board equipments is over four million in October 2004. On the contrary, the VICS, which provides the drivers with the traffic jam information on the express ways and the general roads

through the car navigation system and so on, the number of its on-board equipments rises above 10 million after starting its service in 1996. However, it took about three years until the number of them exceeded one million. Therefore, the spread speed of the ETC system is 1.5 times as much as that of the VICS. Some of the reasons are the drastic reduction in the price of the on-board equipment and the increase of the alleviation effect of the traffic jam by the rise of the ETC tolls. It took six years in the VICS until the rate of the vehicles equipped with the on-board equipment exceeded 30 percent. The reason why the increasing rate of the VICS is not so large is considered to be that the drivers who always suffer with the traffic jam are limited only in the metropolitan areas and as a result, the effect of the traffic jam reduction on the nationwide scale can not be expected.

2.4. New Telematics Services

The following actions are essential for the popularization of the telematics services in future.

(1) The price of the on-board equipment should be drastically reduced to decrease the expense of the users.

(2) The introduction effects of the telematics services should be improved to satisfy the additional worth even if the drivers would pay the call charges by using own mobile phone.

The introduction effect on the nationwide scale can be expected as "safety". The key point of the popularization of the telematics services in future is that the new demands for the "safety" should be found out from the drivers and the passengers who are already provided with the "convenience", "amusement" and "comfort" services.

2.5. Target Systems

A Dedicated Short Range Communications (DSRC) typed wireless communication system is an exclusive wireless network for the ITS and is able to communicate the various information corresponding to the ITS applications. The DSRC system is categorized as Road to Vehicle Communication (RVC) system and Inter-Vehicle Communication (IVC) system. Especially in the development of these systems, the wireless communication environment on the road should be considered in order to transmit the high-speed data of the various information simultaneously [1], [2].

The telematics services are provided through the wireless communication systems. Figure 1 shows the telematics services classification regarding the features of both existing wireless communication systems, such as the mobile phone and the wireless LAN, and the DSRC typed RVC/IVC system. The horizontal axis represents the service area and the vertical axis represents the freshness of information. The service area radius of the mobile phone system is a few kilometers, where we are provided with not only above mentioned the prevention of theft, tracking the stolen vehicles and the emergency call but also the map information update, the traffic information and the regional information. The service area of the wireless LAN is several tens meters, as is well known as hotspot service. The service area of the DSRC typed RVC system is also several tens meters. This system, which provides the vehicles with the driving assistance information from the base station located on the roadside, is expected to open to the new business in the field of the ITS information and telecommunication in the near future. However, those wireless communication systems are defined as a data stored type because the provided information is once collected and then organized in the network servers. It is supposed that the driving assistance information of

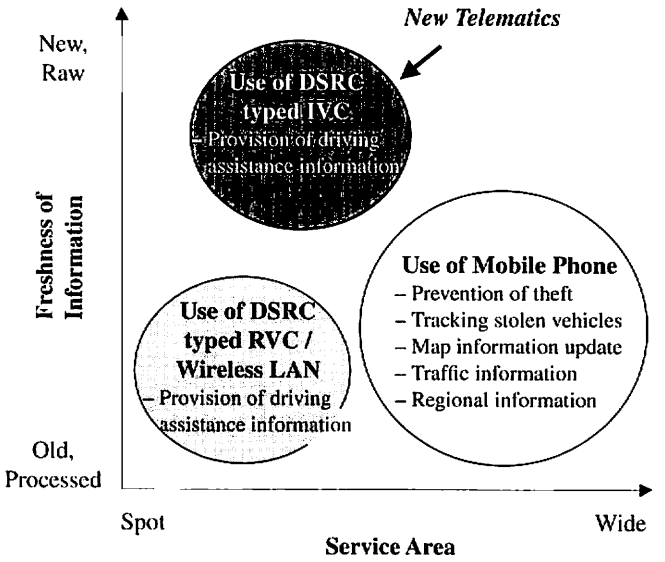


Figure 1. Telematics Services Classification

each vehicle is so local that it takes too long time and too much money for providing all vehicles with the information of same quality.

On the other hand, the service area radius of the DSRC typed IVC system is assumed to be several hundred meters. In this system, the momentary positions of each vehicle and surrounding ones are directly transmitted to each other. Moreover, when the sensors such as a camera and a radar are implemented in the vehicles, each vehicle can transmit the information around it to the surrounding ones immediately. Therefore, the driving assistance information through the DSRC typed IVC system is regarded as most fresh.

3. Road Map of Technology Developments

3.1. Advanced Safety Vehicle (ASV)

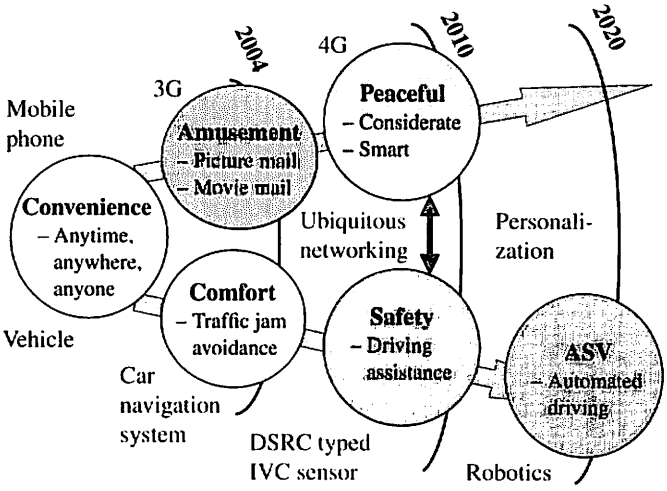
The concept of smart vehicle aims at the development of the ASV (Advanced Safety Vehicle) which would make the vehicles be more intelligent and ensure the high level safety based on the sensor fusion technology utilizing various types of sensors. The DSRC typed IVC system is now under study as the exclusive wireless communication system linked to the ASV developments [3].

The ad-hoc networks between each vehicle and surrounding ones are formed by using the DSRC typed IVC system which communicates the information of the vehicle control and the driving assistance to each other. Therefore, in the group of vehicles, the ITS applications such as the platooning, the diverging/merging support and the stop-and-go are available. The DSRC typed IVC system is also able to exchange the information on amusements such as movie and music between the vehicles.

3.2. Road Map

For realizing the ubiquitous networks, which connect not only persons to persons but also persons to objects or objects to objects, the integrated technology of the information

and telecommunication is under development (e-Japan Strategy II, in August 2003). Figure 2 shows the road map of the technology developments. We enjoy the "amusement" by the mobile phone and the "comfort" by the car navigation system as well as "convenience" of "anytime, anywhere, anyone" in the mobile and motorized society as of 2004. The mobile phone will be advanced into anything that makes us "peaceful" like considerate and smart pets until 2010. On the other hand, the vehicle will be advanced to improve the driver's "safety" such as safety driving support linking to the development of the ASV. Furthermore, it will be able to perform the automated driving corresponding to the needs of the drivers



DSRC: Dedicated Short Range Communications
IVC: Inter-Vehicle Communications
ASV: Advanced Safety Vehicle

Figure 2. Road Map of Technology Developments

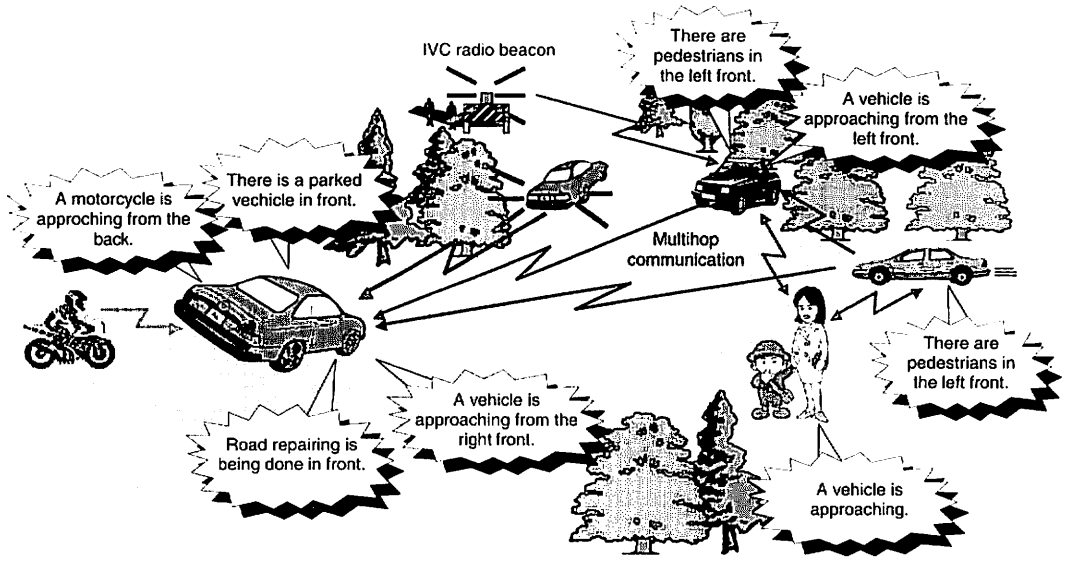


Figure 3. Future Image of Safety Driving Support Applications by using DSRC typed IVC system

until 2020. Figure 3 shows the future image of the safety driving support applications by using the DSRC typed IVC system.

4. Technical Core Competence

4.1. Characteristics of DSRC typed IVC Systems

In the conventional R&D of the wireless communication system, the technical targets were regarded as high speed, high capacity and high quality. The various configurations of the utilization, for example, the wireless LAN system for the fixed communication connected to IP networks and the mobile phone system for the mobile communication, are took into the consideration of the size of the service area and the degree of guarantee of the mobility.

In the DSRC typed IVC system, the information should be quickly exchanged among the vehicles which enter and exit a same service area. Therefore, the real-time performance as well as above mentioned high speed, high capacity, high quality, the service area and the mobility become the important characteristics of the system.

4.2. DSRC typed IVC System toward the ASV

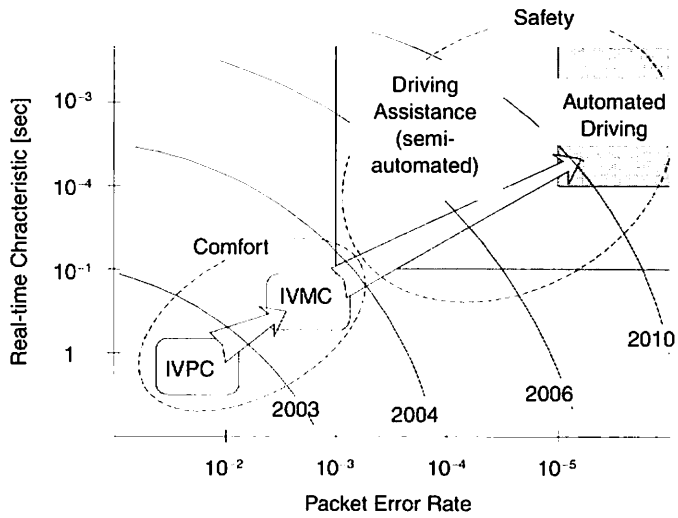
When the service area of the DSRC typed IVC system is not larger than that of the existing Adaptive Cruise Control (ACC) system, it will not be able to expect the contribution to the preventive safety. On the other, it will be able to ensure the higher safety than the ACC system when each vehicle and the surrounding ones accurately exchange the information of their momentary position and velocity. Therefore, it is necessary for the DSRC typed IVC system toward the ASV to optimize both the real-time performance and the high quality selected from the above mentioned six systems characteristics considering the various applications of the ASV. Figure 4 shows the relation between the quality (packet error rate) and the real-time characteristic required to the future wireless communication system which realizes the safety applications.

4.3. Real-time Characteristic

When an incident occurred within the service area of the DSRC typed IVC system, the information should be immediately transmitted to the control system of the vehicles. The quick transmission of the hazard information depends on the packet transmission rate of the DSRC typed IVC system. In the cooperative driving demonstration held on the actual field (DEMO-2000), the rate for the normal data and that for the emergency data were set to 100 milliseconds and 10 milliseconds, respectively. It was verified that the applications such as the platooning and the divergence/merging are possible when the vehicles temporally share the communication services by the two-way communications of their momentary position and velocity within the group [5].

4.4. High Quality Characteristic

The required QoS (Quality of Service) should be satisfied to realize the various applications of the ASV with the high quality. The required QoS of the mobile communication system is generally defined by the loss, the delay and its deviation of the packet. In the case of the conventional mobile communication system, the target average Bit Error Rate (BER) has been about 10^{-3} for the voice call and about 10^{-6} for the data communication, respec-



Packet Length
for Safety: 100 bytes
for Comfort: max. 1500 bytes
IVPC: Inter-Vehicle Picture Communications
IVMC: Inter-Vehicle Movie Communications

Figure 4. Relation between Quality (packet error rate) and Real-time Characteristic

tively. The easy condition of the BER for the voice call is because people have an ability of guessing voices even if it is not enough to catch them. In a wireless communication system with the packet transmission, when the amount of the information per packet is about 1000 bits, the average Packet Error Rate (PER) of about 10^{-3} is equal to that of the conventional mobile communication system.

In the outdoor mobile communication environments, the data transmission performance is degraded by the effect of the multipath propagation. In the DSRC typed IVC system, the maximum transmission rate is assumed to be 4 Mbps using the 5.8 GHz microwave band. Actual field data for the estimation of the QoS is now collecting.

5. Realization of Global Niche Business

It has already been 8 years since we began the R&D of the IVC system in 1996. During this time, the world's first DSRC typed IVC system was developed and led to the success of the DEMO-2000. The advanced DSRC typed IVC system with the high performances of both the real-time and the quality is now aggressively under study in order to reduce the intersection accidents such as crossing collisions and left/right turn collisions which are expected as one of the main goals of the ASV development.

The IVC system has been located in very small niche business domain until last year and regarded as the next-generation wireless communication system like a dream. However, since this year, the number of companies beginning to try the R&D of the IVC system is increasing worldwide, corresponding to the acceleration of the ASV development by the manufacturers of the vehicles. Among them, the company that successfully develops the key technologies realizing the future safety driving support applications will be only able to

become the winner of the global business.

The retransmission of the packets in the wireless data transmission degrades the real-time performance though the possibility of the error-free transmission is increased. In the development of the future DSRC typed IVC system, the key technologies optimized to each safety application should be integrated based on the high level wireless technologies considering the trade-off relationship between the real-time characteristic and high quality. Furthermore, the cooperative R&D between the researchers of the wireless communication, the control, the navigation and the surveillance technologies should be also performed.

6. Conclusion

With the progress in the ubiquitous networks, the mobile and motorized society will turn into the society where every people can live with the inward "security" by the technologies ensuring the "safety". For the safety driving support applications, the advanced wireless technologies, which satisfy the required QoS, will become the technical core competences of the future DSRC typed IVC system. It should be anticipated that the future changes in the economic situation would push the researchers in the company to challenge the new technical regions drastically. However, every researcher should innovate the conventional technologies keeping in mind that "necessity is the mother of invention".

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