DSRC-Type Communication System for Realizing Telematics Services

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The decisive factor for the popularization of telematics services in the future is the ability to produce advanced services that match the needs of drivers and passengers. The Dedicated Short Range Communications (DSRC)-type of wireless communication system, which is being developed for the Intelligent Transport Systems (ITS), is one of the broadband wireless systems contributing to the improvement of driver and passenger needs, such as convenience, entertainment, comfort and safety. In this paper, the possibility of applying this system to telematics services will be explored. Further, a description of the future prospects for ubiquitous networking will be provided, in the knowledge that the existence of information communication equipment mounted vehicles will remain.

Introduction

In the near future, existing information communication networks will transform into ubiquitous networks. The ability to support (1) borderless connectivity and (2) seamless portability of the content for mobile telephones, PDAs, notebook computers and others, from a diverse range of information communication devices, is a feature of the ubiquitous networks. Item (1) is the connectivity of mobile telephones, PDAs, notebook computers and others, from a diverse range of information communication devices using the Internet, which is in every aspect of our daily lives. Item (2) represents the seamless transmission of rich content, such as voice and moving images (aside from data transferred between information communication devices), by using voice transmission technologies, such as VoIP, along with highly efficient image compression technologies, such as MPEG-4 or MPEG-2. The research and development of multi-modal broadband networks that can transmit information smoothly between different network modes (such as fixed and mobile, wired and wireless, telecommunication and broadcasting) is being promoted for the realization of ubiquitous networks.

As for the wired systems of broadband networks, broadband IP networking has progressed to transmission rates of 24Mbit/s and 100Mbit/s, using ADSL and optical fiber connections. While for wireless systems, an Ultra Wide Band (UWB) system was recently realized, which is drawing attention as a means to realize ubiquitous networks at home. The transmission of high-definition images, with a targeted transmission rate of up to a maximum of 1Gbit/s is assumed for the system[1]. For mobile communication systems that presuppose mobile environments, transmission rates of 2Mbit/s standing still and 384kbit/s in motion, have been realized by the third generation mobile telephone (3G) system (IMT2000). Furthermore, in the research and development of the fourth generation mobile telephone (4G) system, which is currently aggressively pursued worldwide, a broadband wireless system with a targeted transmission rate of 100Mbit/s, which is equivalent in speed with optical fiber networks, has been set as a development target.

Needless to say, however, for the broadband wireless systems of the future, the selection of services offered to users will be far more important than the increase in transmission rates. Citing an example, let us assume that there is a moving image streaming transmission service. Even if a mobile terminal is capable of receiving the data stream of moving images, with an image quality equaling that of digital satellite broadcasting (at a transmission rate of 6Mbit/s, which is a standard rate for MPEG-2), it is a specification that is far too high for the device, unless the mobile terminal has a display large enough to receive the images.

Systems that meet the needs of vehicle drivers and passengers are expected of the Intelligent Transport Systems (ITS). In recent years, major domestic automobile manufacturers have started offering telematics services, made possible by adding information communication functions to vehicle navigation systems. Aside from the vehicle location display function, provided by working with the global positioning system (GPS), the system offers information that responds to the needs of drivers and passengers via the mobile telephone system.

Current Status of the DSRC-Type Wireless Communication System

The wireless communication systems for the ITS can be classified into two broad categories including the Road to Vehicle Communication (RVC) systems and the Inter-Vehicle Communication (IVC) systems. The development of DSRC-type RVC systems, with a consideration for the communication environment of the roads and IVC systems, will be especially necessary[2) 3)] in order to realize simultaneous high-speed transmissions of various information.

Table. 1 Main specifications and features of the DSRC-type RVC

Classification		DSRC-type RVC	
ARIB STD		T55	T75
Service		ETC	ETC Information Shower
Specifi-cations	Frequency band	5.8GHz band	5.8GHz band
	Frequency channels	4ch	14ch
	Dedicated bandwidth	8MHz	4.4MHz
	Transmission rate	1Mbit/s*1	1M*1/4Mbit/s
	Wireless access method	TDMA-FDD	
	Modulation method	ASK	ASK/QPSK
	Service area (reference values)*2	up to 30m	up to 30m
Features	Mobility	Consideration for the reduction of time during link establishment	
	Other system interference	No interference (dedicated frequency assignment)	
	System capacity	Allotment by number of slots (maximum eight slots per channel)	

*1) Since the ASK is the split phase coded method, the modulation speed will be 2,048 kbaud.
*2) Areas depend on the environment.

(1) DSRC-type RVC system

Within the commercial standards (ARIB STD) already established with the Association of Radio Industries and Businesses (ARIB) for the DSRC-type RVC system of the 5.8GHz band, there is the ARIB STD-T75. This can be applied to the information shower service in addition to the ETC that is aside from the ARIB STD-T55, dedicated to the ETC. The main specifications and features of the DSRC-type RVC are described in Table 1. The ARIB STD-T55 uses a frequency band of 5.8GHz, two 8MHz dedicated frequency bandwidth channels on each uplink and downlink direction, making a total frequency band of four channels. Further, the Time Division Multiple Access (TDMA) and Frequency Division Duplex (FDD) have been adopted as wireless access methods, while the digital amplitude modulation, by the Amplitude Shift Keying (ASK), has been implemented as the modulation method. Furthermore, the maximum number of slot allotments for each channel is eight. Two-way communications can be conducted, with a maximum transmission rate of 1Mbit/s to a maximum of 16 vehicles, within a service radius of 30m. Features of this system include the speedy execution of authentication and charge processing to vehicles as they drive through the tollgates and while they are still within the communication service area. The ARIB STD-T75, on the other hand, is a further development of the wireless communication technology of the ARIB STD-T55. It makes it possible to provide the so-called information shower service with the ETC, including payments for purchases made at drive through stores and filling stations, various information relating to parking management, logistics, etc. The frequency allocations of the DSRC-type RVC system is shown in Fig. 1. In comparison with the ARIB STD-T55, the ARIB STD-T75 has narrower intervals between the center frequency allocations, with compression of the dedicated bandwidth.

More specifically, with the frequency band of 5.8GHz, a total of 14 channels of frequency band are used, with seven channels of 4.4MHz used for each uplink and downlink dedicated frequency band, as shown in Table 1.

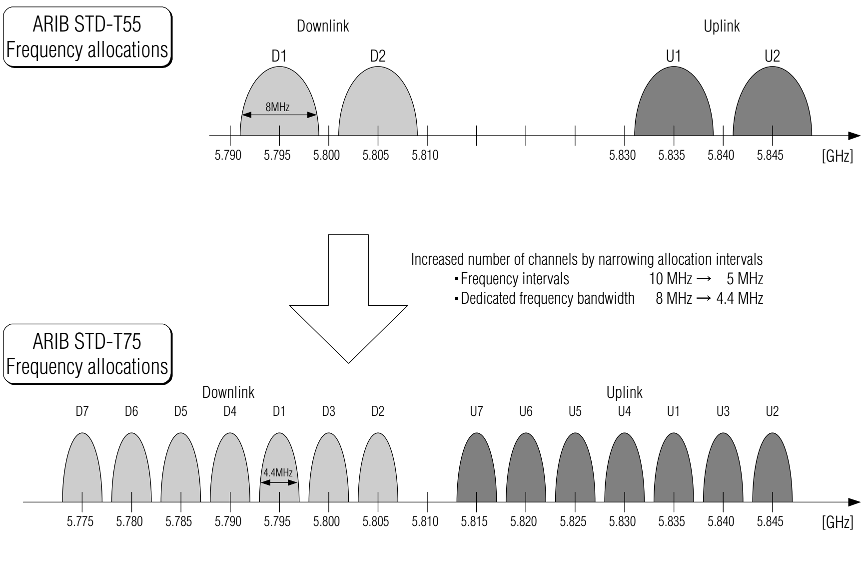

Fig. 1 Frequency allocation for the DSRC-type RVC system

The wireless access method is TDMA-FDD, while the number of slots allotted per channel is eight, as with the ARIB STD-T55. However, since broadband data transmission is conducted with a narrow dedicated bandwidth while in motion, the Quadrature Phase Shift Keying (QPSK), a digital phase modulation, is adopted as the modulation method, aside from the ASK. This makes it possible to conduct two-way communications at the maximum transmission rate of 4Mbit/s with a maximum of 56 vehicles within a service radius of 30m. A feature of this system is that it is possible to use either the ETC alone, the information shower alone, or a combination of the ETC and information shower. Further, with a maximum transmission rate of 4Mbit/s, together with the transformation of the network into a broadband network, it is possible to download rich content, such as moving images.

(2) DSRC-type IVC system

Development of the Advanced Safety Vehicle (ASV) is progressing. The ASV assures a high degree of safety by raising the intelligence of the vehicle with sensor fusion technology that utilizes information from multiple, various sensors. A DSRC-type IVC system, capable of conducting two-way communications with on-board equipment to exchange various information, is being considered as a wireless communication system, which is linked with the development of the ASV.

The DSRC-type IVC system forms an ad hoc network in which two-way communications are conducted. Vehicles communicate with other vehicles traveling in the vicinity, to exchange vehicle control information and driving assistance information. For this reason, vehicles that share communication services, form a group temporarily, wherein the use of ITS applications, such as concatenated driving, junction support, stop & go, etc., is possible. An actual field cooperative drive experiment (DEMO-2000) has already been conducted. With this experiment the use of ITS applications, such as adulation driving and junction support, were validated[4) 5) 6) 7) 8)] for temporarily formed vehicle groups that used common communication services through two-way communications, to share vehicle control information, such as current position and speed.

The DSRC-type IVC system can also be used for the exchange of amusement information between on-board devices, such as movies or music. A system that offers “Sha-sha-kan Tsushin”[*1)], an Inter-Vehicle Picture Communication (IVPC) system for the instantaneous transmission of static images, has also been developed[9)].

Possible Application for Telematics Systems

(1) Current status of service

The latest telematics services offer road traffic information, the reception and transmission of electronic mail, online shopping and the availability of amusement information for passengers. This has been made possible via the Internet connected through the mobile IP connection service, aside from hands-free mobile telephone and simple telephone services that utilize voice recognition. Further, by using information that is linked with the vehicle's location information obtained from the GPS, which is a basic function of vehicle navigation systems, it would be possible to transmit distress signals for emergencies or the automatic tracking of stolen vehicles.

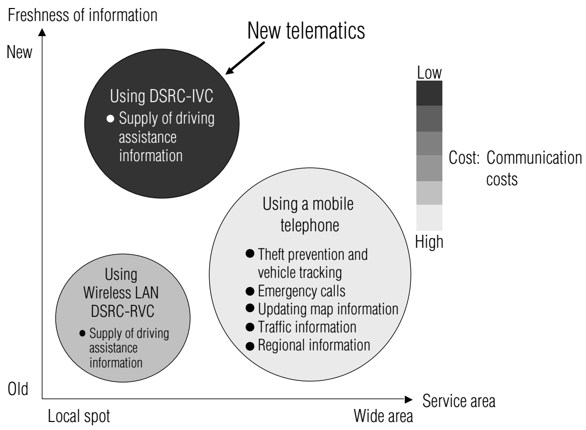

Fig. 2 Classifications of telematics services

(2) Classification of telematic services

Telematics services will be provided through wireless communication systems. Classifications of telematics services are shown in Fig. 2, with consideration for the characteristics of existing wireless systems, such as mobile telephones and wireless LAN, as well as the DSRC-type RVC system and the IVC system. The horizontal axis represents the service area, while the vertical axis represents the freshness of information. The service area of mobile telephone systems is an area with a radius of a few kilometers, within which the aforementioned theft prevention, vehicle tracking, emergency call services, as well as map information updates, traffic information and regional information are all available. Further, the service area of wireless LAN has a radius of several tens meters, with the hot-spot service that is already a familiar service. The service area of the DSRC-type RVC system, incidentally, also has a radius of several tens meters. Business developments are expected in the near future for this system, which will provide driving assistance information to vehicles from wireless base stations installed on the roadsides within the domain of ITS information communications. A characteristic of these wireless communication systems is that the information provided is first collected and sorted out on a network server. Driving assistance information for vehicles is extremely local information. If information of a similar quality is to be provided to all vehicles, it is anticipated that an immense amount of time and investment will be required for the collection of information.

The service area of the DSRC-type IVC system, on the other hand, is assumed to be several hundred meters in radius. With the DSRC-type IVC system, the current location of a vehicle, as well as the locations of other vehicles in the vicinity, are exchanged through direct two-way communications, conducted via IVC devices mounted on individual vehicles. Further, if there were sensors, such as a camera or radar, mounted on an individual vehicle, it would be possible to immediately

*1) “Sha-sha-kan Tsushin” is a registered trademark of Oki Electric Industry Co., Ltd.

pass on information to other vehicles in the perimeter surrounding the vehicle . Thus, the driving assistance information provided by the DSRC-type IVC system would be extremely fresh.

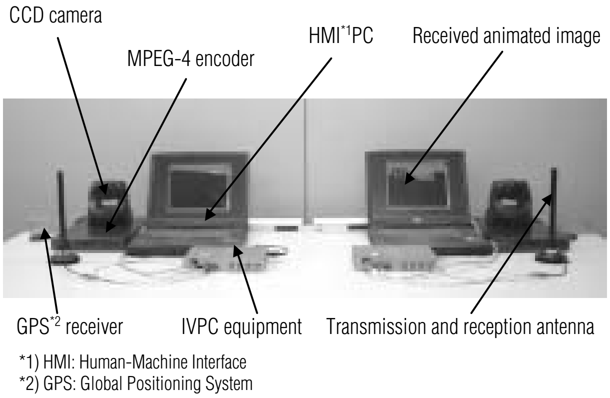

Fig. 3 IVPC system for moving image transmission

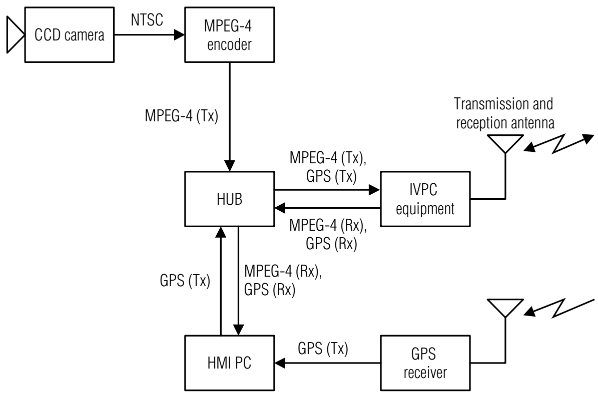

Fig. 4 System block diagram of the IVPC system for moving image transmissions

(3) IVPC system for moving image transmissions

An IVPC system has been developed that sends moving images, compressed in MPEG-4 format, instantaneously at 4Mbit/s. These images can show forward view conditions of disaster, accidents and congestion, as well as conditions of the interior of a passenger vehicle. An external view of this system is shown in Fig. 3.

A system block diagram of the IVPC system, for moving image transmission on individual vehicles, is shown in Fig. 4. This system is comprised of IVPC equipment, MPEG-4 encoder, HMI PC, CCD camera and GPS receiver. The IVPC equipment, MPEG-4 encoder and HMI PC are connected to each other via a hub with an Ethernet cable.

Future prospects for Ubiquitous Networking

Internet connection is assumed for the roadside wireless base stations of the DSRC-type RVC system. The DSRC-type IVC system, on the other hand, is comprised of autonomous and distributed networks for individual mobile stations and do not currently have the capacity to connect to the Internet. From the perspective of improving user convenience, it will be necessary in the future, to develop a high-end DSRC system that can provide the three services of the ETC, information shower and safe driving assistance.

The high-end DSRC system of the future will use the DSRC-type IVC system to provide inter-vehicle safe driving assistance information at all times, while the ETC or information shower services will be provided when passing through local service areas of the DSRC-type RVC systems. In particular, when an information shower service is provided and if the Internet connection is assumed, then the system will temporarily be comprised of a ubiquitous network.

Conclusion

Whether the telematics service will become popular or not will depend on the extent of the response that the service will be able to provide to the diverse needs of drivers and passengers. When we consider the needs of drivers and passengers, taking into account that they are part of the mobile population, then there is a need for improvement over and above the “convenience” and “entertainment” that are already being provided by mobile telephones and vehicle navigation systems. Further, the interests of the driver to arrive at the destination, safe while avoiding congestion, is assured. That is to say, improvement of “comfort” and “safety” while driving.

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