Interactive Wireless Communications for Wider-range ITS Services
— Road-vehicle Communication and In-car Network —

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OVERVIEW: For the ITS (intelligent transport systems), various services are being considered and forms of communication that are appropriate for each service are being proposed. There is a strong need for the ability to conveniently obtain required information on demand, to conveniently process transactions, and two-way wireless communication is essential as the form of communication for those purposes. Furthermore, in order to provide the vehicle driver with suitable services, both communication between vehicles and roadside, and communication among the devices within the vehicle are needed. For en-route communication, attention is on the mobile cell phone as a means of wide-range communication with Internet terminals and voice service terminals and on DSRC (dedicated short-range communication) as a means of narrow-range communication with electronic settlement terminals such as those of the ETC (electronic toll collection) system. Also, for communication among devices within the vehicle, the "Bluetooth" specifications hold promise for cableless interconnection of on-board devices. Hitachi, Ltd. has been involved in the setting of communication standards and the development of communication devices. In future work we will take up the tasks of developing communication technology for fusing various communication media and constructing a system towards implementing a seamless ITS communication environment.

INTRODUCTION

VARIOUS networks for 21st-century mobile communication are appearing, such as DSRC (dedicated short-range communication), which is a narrow-range communication system for ETC (electronic toll collection: automatic collection of charges) systems, next-generation mobile communication systems, ground-wave digital broadcasting, and the "Bluetooth" standard for inter-terminal communication. Automobile users expect to be able to connect to the networks seamlessly and to be able to use the optimum communication for the purpose at hand.

In the midst of this situation, the cell phone is the most popular communication terminal, and demand will continue to expand in the 2000's.

DSRC is drawing attention as ETC begins operation, and its application as a communication device mounted on automobiles is expected.

Intra-vehicle communication is also regarded as very important for providing various services to the user, and the "Bluetooth" standard is the focus of attention as a means of cableless inter-connection among the various devices installed in the automobile, such as cell phones and car navigation devices.

Here, assuming popularization and use in the ITS field (See Table 1), we briefly describe the "cell phone" for wide range communication, "DSRC" for narrow-range communication, and "Bluetooth" for intra-vehicle communication and their future development.

ROAD-VEHICLE COMMUNICATION

Cell Phone

Cell phone features

(1) Wide communication range: Cell phones are connected via wireless lines to base stations that are placed at intervals from several kilometers to several tens of kilometers apart. By changing the base station to which the terminal is connected is from one base station to another during terminal movement, uninterrupted communication over a wide area is possible.

(2) Information provided by voice: Because information can be provided and input by voice, without a display device, it can be used with no burdening the driver.

(3) Internet connectivity: Phones that have Internet

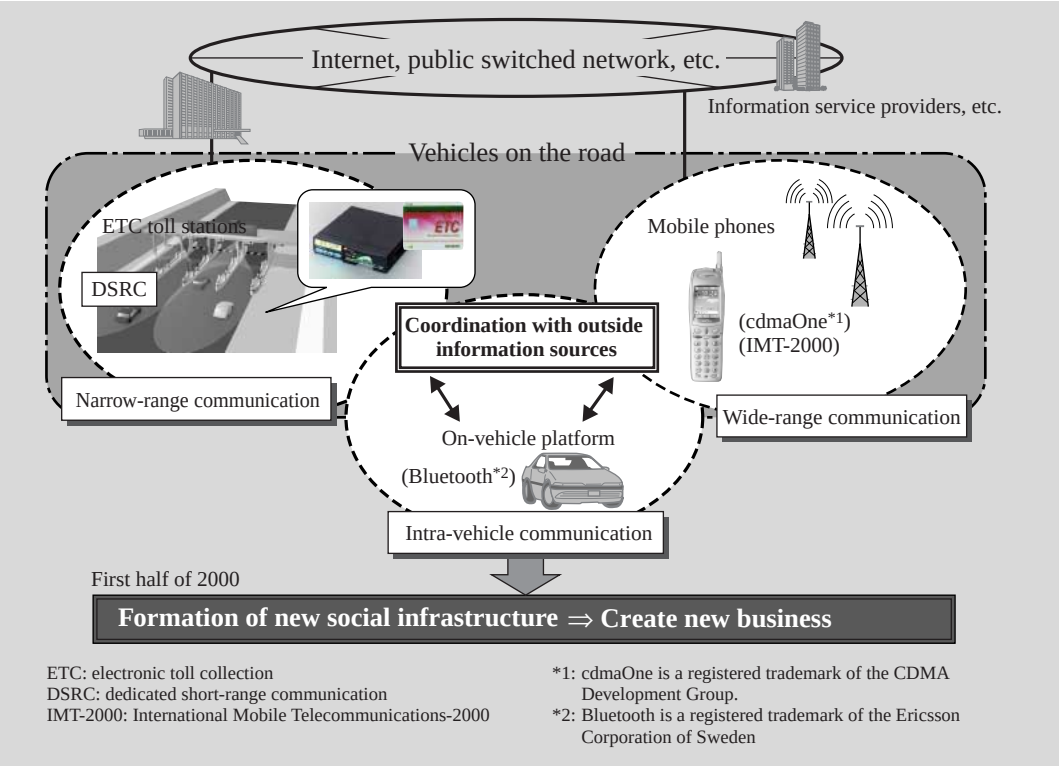

Fig. 1— The Information Communication Environment Surrounding Automobiles.
For both communication between vehicles en route and communication within the vehicle, various communication environments have been established and various services are being offered to users.

TABLE 1. Communication Media to be Used in the ITS
System applications are expected to take advantage of the special features of each communication medium.

Capability	Road-vehicle communication		Intra-vehicle communication
	Wide-range communication	Narrow-range communication	
Data transfer speed	64 kbit/s (cdmaOne)	1,024 kbit/s	1 Mbit/s
Communication range	Tens of kilometers	About 30 m	About 10 m
Tolerance of movement	About 100 km/h	About 180 km/h	Walking
Frequency band	2 GHz	5.8 GHz	2.4 GHz

connection functions such as the WAP (Wireless Application Protocol) are appearing and it is steadily becoming possible to access even more types of information.

Faster data communication

The way in which cell phones are used is undergoing a transition from the conventional emphasis on voice to e-mail and Internet data communication applications and the importance of data transfer speed is increasing. In response to that demand, Hitachi, Ltd. has developed the cdmaOne cell phone product. On the market so far are model C201H, which is the first in Japan to implement the WAP for using cell phones to access the Internet, model C302H, which can handle the world's fastest 64 kbit/s packet communication speed, and model C309H, which features a color liquid crystal display (Fig. 2).

Fig. 2— Appearance and Main Specifications of the "C309H" cdmaOne Cell Phone.
The continuous communication time is about 170 min. The continuous stand by time is about 190 h. It weights 89 g having approximate dimensions of 130 × 19 × 46 (mm).

The current mainstream cell phones are referred to as second-generation communication and various

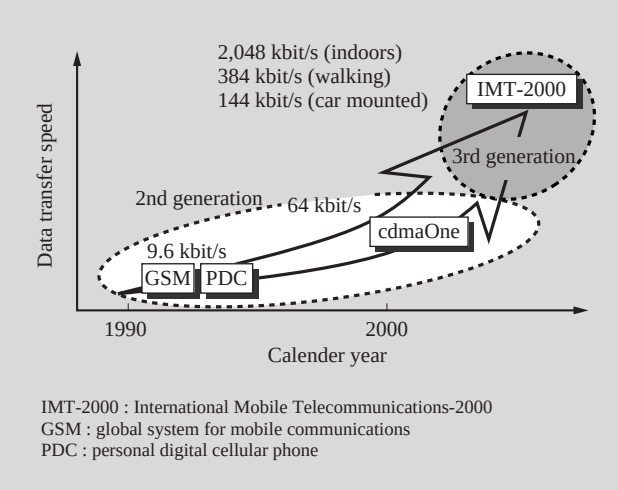

Fig. 3—Trend in Cell Phone Communication Speed.
The introduction of the third-generation cell phone, which will allow yet faster data communication even during movement, is drawing near.

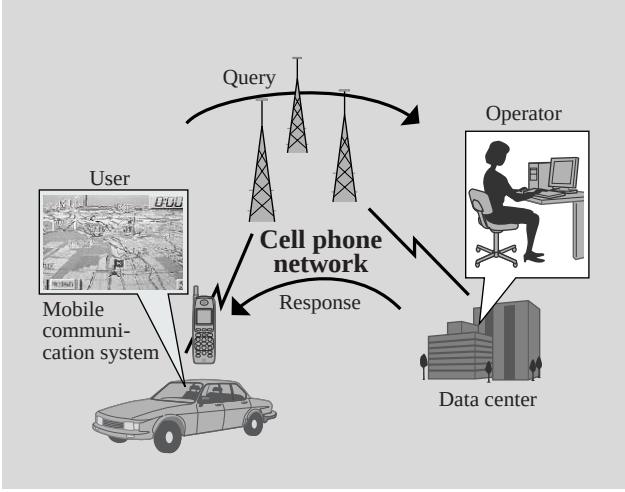

Fig. 4—Example of Cell Phone Use.
By using the cell phone as an input/output device for voice and data, usability is greatly enhanced.

countries and regions are using different systems. The cdmaOne is one such system that realizes the same 64-kbit/s data transfer rate as fixed digital lines (Fig. 3). In addition, it uses next-generation basic technologies such as those listed below and is suitable for a mobile environment.

(1) Stable connection in which disconnection is suppressed is made possible by a technique in which up to three multi-path signals are received and integrated at the receiver.

(2) More continuous communication during movement is achieved by a technique in which the mobile unit communicates with multiple base stations on the same frequency.

Application of cell phones to ITS and future development

An example of the cell phone applied to the ITS is shown in Fig. 4. The operator of an information provider service confirms the users request by a voice call and then sends the required information to a device in the users vehicle. Using the cell phone makes it possible to also contact the store or other such source directly concerning the information, increasing usability. In the future, the automation of systems and diversification of service content through voice recognition and voice synthesis technology and application to music and map distribution services and other such services that take advantage of high-speed communication is expected.

DSRC

Overview of DSRC and its special features

DSRC is a communication system that was developed for ITS road-vehicle communication applications and is being applied to VICS (Vehicle Information and Communication System) and ETC road-vehicle communication. Communication is conducted between roadside devices that are installed on the road and devices that are installed in vehicles. The communication range of a single roadside device is small (from 3 to 30 m) and this system is suitable for use in transaction settlement and other such uses. DSRC sends data to the vehicle by the kinds of

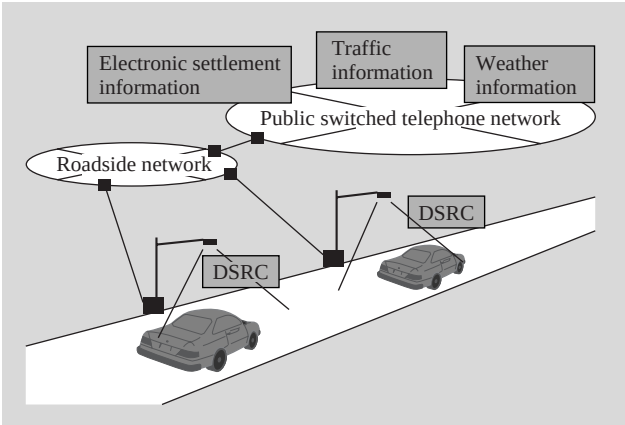

Fig. 5—Position of DSRC in the Network.
With DSRC, data is sent and received between roadside devices that are installed on the road and vehicle-mounted devices that are installed in the vehicle.

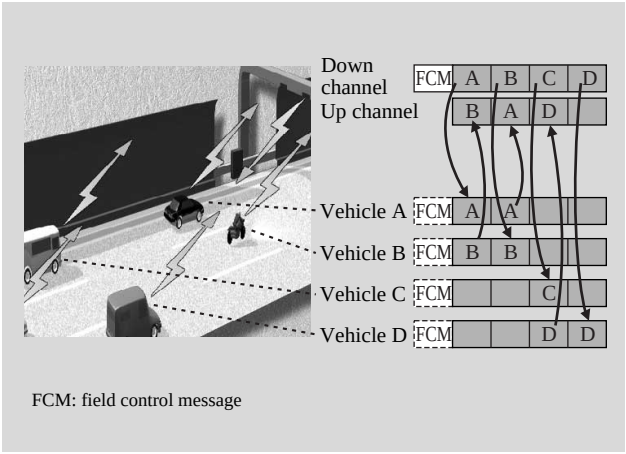

Fig. 6— DSRC Communication Protocol. Assigning one slot to one vehicle makes it possible to communicate with multiple vehicles simultaneously.

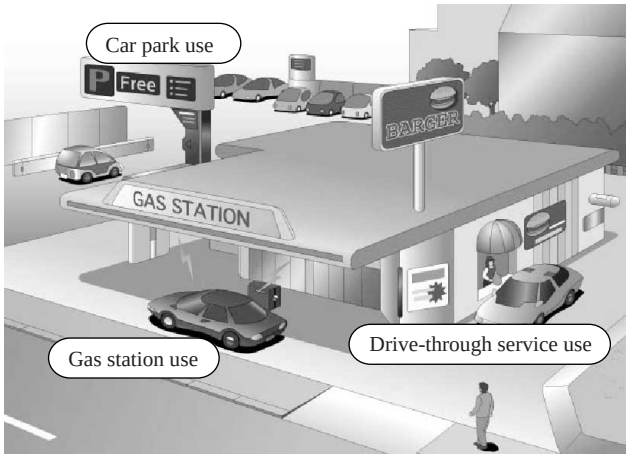

Fig. 7— Example of Extension of DSRC Applications. Other important future applications include the extension of cashless transactions by means of DSRC to gasoline stations, drive-through services, car parks, and so on.

communication paths shown in Fig. 5.

The main features of DSRC are listed below.

(1) Transfer speed: 1,024 kbit/s

Communication is possible even for high data transfer volumes and high traveling speeds, so this system can cope with future services that handle large volumes of data.

(2) Communication system: Active method (transceiver)

In this method the roadside devices and vehicle-mounted devices both have transmitters that can send and receive with low transmission and receiving power. That makes it possible for multiple devices to use the same frequency in relatively close proximity, which allows efficient frequency utilization.

(3) Access method: Adaptive slotted-ALOHA method

Communication is conducted in time division, with units of frames that have multiple slots. Because one slot is allocated to one vehicle, communication with multiple vehicles within a limited zone is possible.

Hitachi, Ltd. has contributed to the development and standardization of DSRC that has the above features and has created ETC roadside device and vehicle-mounted device products. We are also actively participating in work to make DSRC an international standard.

Expansion of DSRC

DSRC, which uses an active communication scheme, allows high-speed data transfer and so extension to various applications that include even IP (Internet protocol) connections can be considered. In particular, transaction settlement applications that take advantage of the feature of high-speed communication

TABLE 2. The Bluetooth Specifications
Specializing in short-range communication allows the possibility of lower system cost.

	Bluetooth	IEEE802.11
Application	Short-range communication among devices	Wireless LAN
Voice lines	3	Not specified
Number of devices that can be connected	7	Not specified
Radio frequency	2.4 GHz band	Same as left
Frequency spreading method	Frequency hopping	Same as left
Data transfer speed	1 Mbit/s (721 kbit/s, actual)	1 Mbit/s/ 2 Mbit/s
Transmission power	Standard 1 mW	1 mW to 1 W
Receiver sensitivity	-70 dBm@10^{-3} BER	-80 dBm@10^{-5} BER (1 Mbit/s)

BER: bit error rate

in small zones are expected and introduction into various settlement situations should continue steadily into the future (See Fig. 7).

OVERVIEW OF BLUETOOTH

To allow the information that has been sent to the vehicle to be used seamlessly within the vehicle, intra-vehicle communication among the devices in the car is also needed.

Bluetooth has been the focus of attention as a means of communication between the cell phone and the car navigation system or other on-board devices. This system has the feature of suppressing interference with other devices by using the 2.4 GHz ISM (Industrial, Scientific, Medical) band, which does not require a license anywhere in the world, and spread spectrum technology (Table 2). It is suitable for intra-vehicle communication, because voice communication is possible and communication is not prevented by the presence of obstacles. Hitachi, Ltd. is proceeding with the development of products in this area.

Bluetooth, which links devices by means of wireless communication, is expected to extend to various uses other than simply replacing cable wiring. For example, simply carrying a Bluetooth-enabled cell phone into a vehicle can make it possible for the driver to connect to the navigation system and operate audio equipment, the air-conditioning system or other such equipment by voice (Fig. 8).

CONCLUSIONS

Here, assuming the popularization and use of ITS, we have described the special features and future development of three communication media, which are the "cell phone" for wide-range wireless communication, DSRC for narrow range, and Bluetooth for cableless inter-connection in the vehicle.

Fig. 8— Example of Bluetooth Application to Intra-vehicle Communication.
Elimination of complex wiring and creation of new forms of use.

We expect that the future will bring further evolution toward an information society, with a variety of services being made available to the passengers of automobiles by means of information provision systems and automatic transaction settlement systems, various kinds of reservation systems, and so on, centering around Internet access.

Making good use of accumulated communication technology, Hitachi, Ltd. will continue work on the development of an environment for stable and seamless communication to provide users with convenient ITS services.

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