System-on-chip Semiconductor Solution and Reference Platform for Automotive Information Networks

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OVERVIEW: The needs of automobile drivers are moving in the direction of information in addition to safety and advanced control. With the shift toward information functionality, content services such as searching for information on the Internet, music and picture broadcasting, settlement of charges, traffic information, and emergency call service can be enjoyed while driving an automobile. This is all accomplished with cell phones, wireless LANs (local area networks), road to vehicle communication and other such equipment serving as the infrastructure. Toward that end, vehicles must be equipped with information processing devices that have mobile multimedia functions and communication terminals, so there is a strong need for an automotive information system that can serve as a platform for this by integrating these functions (see Fig. 1). Hitachi is introducing this kind of automotive information platform. We are also developing a variety of interface and middleware products for various kinds of communication and multimedia processing.

INTRODUCTION

IN automobiles of the ITS (intelligent transport systems) era, there is expected to be cooperation between information and communication systems that have advanced functions and real-time control systems via an information and control network. Particularly in information systems, cooperation between communication infrastructures and the automobile is progressing, and various services and social effects are expected. To make these kinds of information

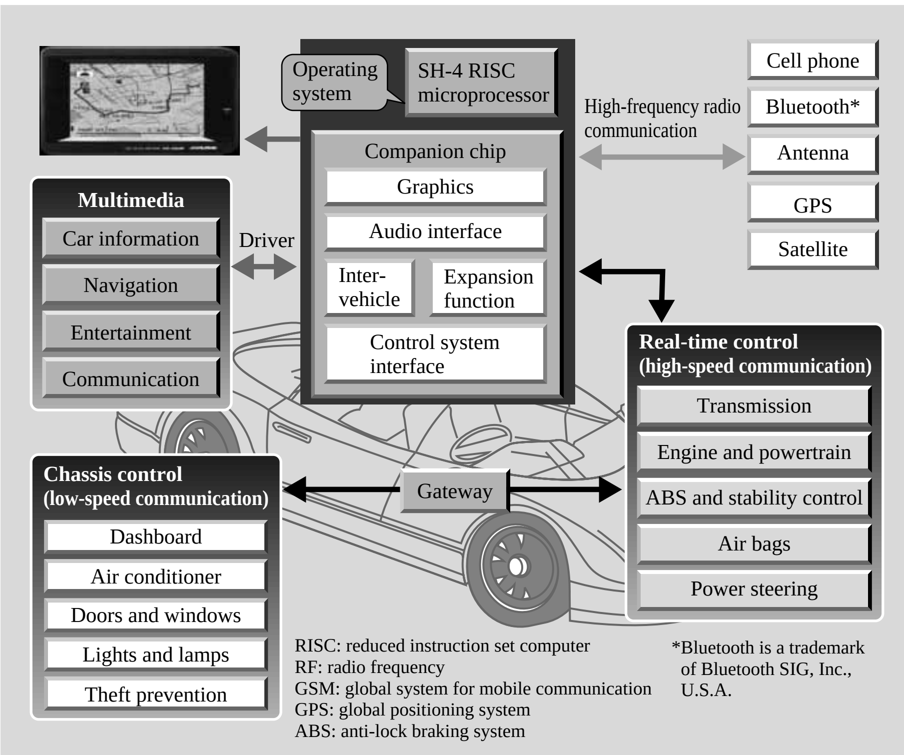

Fig. 1—Automobile Information and Control Platform.
Automobiles of the ITS era will have a communication terminal and data processing devices installed in addition to a control system. It will be possible to enjoy comforts such as information services and driving safety by means of an ITS communication infrastructure resting on a platform in which there is cooperation between the information system and the control system.

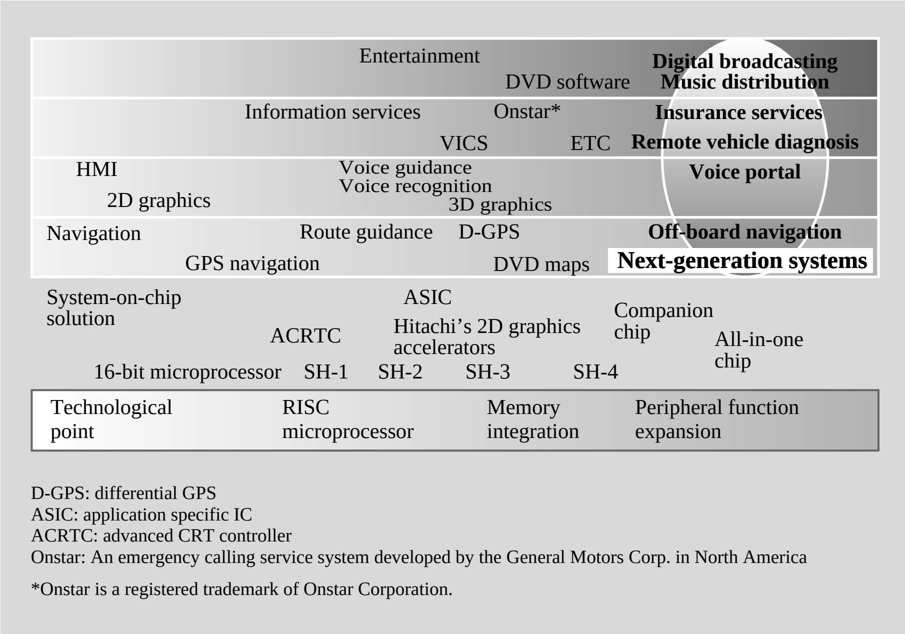

Fig. 2—Trends in Automobile Information Systems.
There is an evolution from navigation to a total system that includes an HMI, information services and entertainment services. To cope with this trend, the system-on-chip solution is also moving in the direction of integrating all of the necessary functions in an all-in-one chip.

services for automobiles even more attractive, there is a need for advancement of automotive information devices, including improved communication protocols, security, and diversification of the HMI (human-machine interface), as well as advanced processing of images, graphics, etc.

Here, we describe semiconductor device technology for supporting the advancement of an ITS-oriented automotive information system, beginning with a high-speed processor that meets the need for multimedia processing. We then continue with Hitachi's interface and middleware products, which include hardware and software solutions for control and data communication protocols, voice and music codecs, a voice interface for the HMI, development tools that allow fast and easy development and evaluation of an automotive information platform, and a system development environment.

SYSTEM-ON-CHIP SOLUTION

From Navigation to Car Information System

In the 1980s, the GPS (global positioning system) was well researched, and car navigation systems that incorporated that technology appeared in the consumer market at the beginning of the 1990s. At the beginning, the systems provided only a simple map and route guidance, but later the human interface functions were strengthened with voice input and output, 3D map display, etc. Progress is continuing in the directions of communication that extends to systems outside the vehicle such as VICS (vehicle information and communication system) and ETC (electronic toll collection) system, information services such as connection to the Internet via cell phones, and entertainment, such as the playback of DVDs (digital versatile discs). In other words, the ITS is truly achieving a transformation from a single-function car navigation product into an integrated multifunction solution, which is the automobile information system (see Fig. 2).

Hitachi has supplied the "system-on-chip solution" to support the transformation described above. The microprocessors range from 16-bit devices to RISC (reduced instruction set computer) devices in pursuit of high performance, and in most cases the SH-4 microprocessor is used. For display control, there is Hitachi's 2D (two-dimensional) graphics accelerators, which employs UMA (unified memory architecture). That technology unifies the memory required for each function, supporting construction of a compact system with fewer components[1]. There is also an ASIC that was developed to incorporate the functions that are required by an automobile information system.

In the future, aiming at the best solution for this field, we expect to advance on to a companion chip for the CPU (central processing unit) that incorporates the ASIC and the 2D graphics accelerators display control, and then further on to an "all-in-one chip" that incorporates the CPU as well. That will make it possible to provide a platform that integrates complex system designs on a chip and reduces the number of peripheral devices in the system.

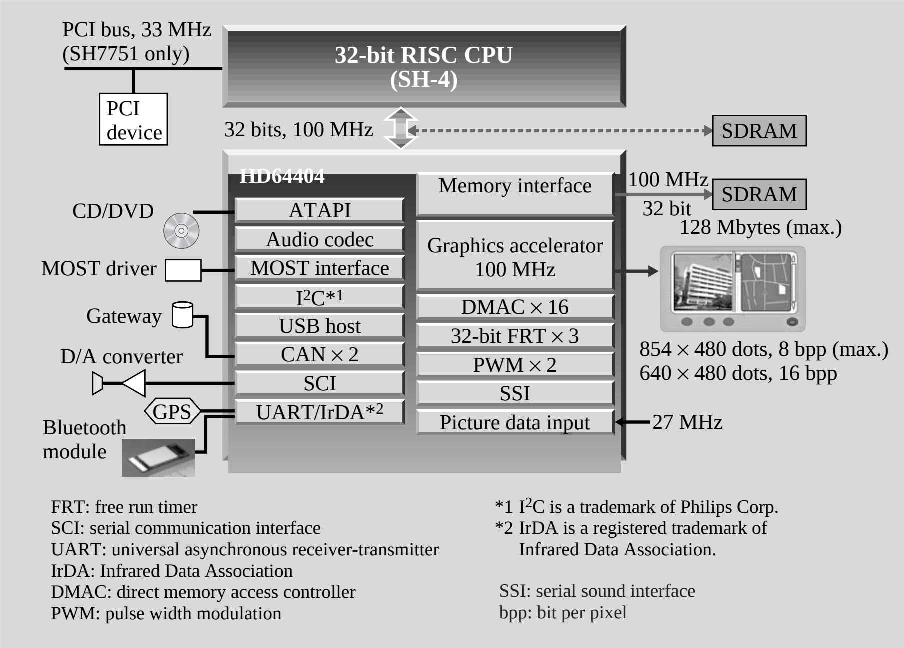

Fig. 3—Example of System Configuration Using SH-4 and Companion Chip.
The HD64404 is a companion chip that can provide solutions together with the SH-4 as a set.
It incorporates all of the interfaces required by automobile information systems, from display control to advanced automotive networks such as MOST and CAN.

SH-4 RISC Microcomputer Incorporates the Most Advanced Information System Technology

The SH-4 incorporates the most advanced information system technology into an embedded microprocessor. This device features various functions, such as a super-scalar architecture, which allows execution of two instructions at the same time, and the floating-point calculation function that is required by car navigation applications, providing power for complex computation that has not previously been available in an embedded microprocessor.

The SH-4 models include one that has a 64-bit system bus, one that has a 32-bit system bus and a 32-bit PCI (peripheral component interconnect) bus. At this time, enhanced versions of those devices that feature operating speeds from 200 to 240 MHz have already been developed (SH7750R and SH7751R). They have a 2-way 16-kbyte instruction cache and a 32-kbyte 2-way data cache with way prediction. Both capacity and number of ways are being doubled. Furthermore, development toward an ASSP (application specific standard product) with a built-in SH series CPU for an all-in-one chip solution using Hitachi's system LSI (large-scale integration) design platform is also easy.

HD64404 Companion Chip with Built-in Automobile Information System Interface Function

As a solution at the current semiconductor integration scale, we developed the HD64404 as a companion chip for the SH-4. The HD64404 incorporates the display control and peripheral ASIC functions. This is a device that integrates all of the interface functions that are required by the automobile information system other than the CPU (see Fig. 3). It has the expandability through connection to the system bus or the PCI bus of the SH-4. The device also has an interface for 100-MHz SDRAM (synchronous dynamic random access memory). This configuration also has the special feature that when the companion chip is connected to the SH-4 by the MPX (multiplex) bus connection method, the UMA allows the graphics memory to be used for the main system memory as well, allowing reduction in the number of memory devices.

The HD64404 series provides useful interfaces, including a display control function, audio interfaces such as the SSI, a control system network interface (CAN: controller area network), advanced automotive network (MOST: media oriented system transport), ATAPI (advanced technology attachment bus packet interface), USB (universal serial bus), and SCI .

Ultimate All-in-one Chip Solution

The next step beyond the microprocessor and companion chip configuration, the "all-in-one chip" has already been described. With the all-in-one chip, not only are the microprocessor, display control and ASIC all integrated on a single chip, it is also possible to unify the external memory.

Hitachi has so far proceeded with the integration of image memory into one place for
(1) display data memory for its 2D graphics accelerator's display control device,
(2) graphic memory for composing the image of the next frame in parallel with the display of the current frame or image data memory,
(3) command memory for feeding instructions to the drawing function, etc.

With the all-in-one chip, we plan to unify the main memory and the memory for peripheral functions as well. Furthermore, for automobile information systems, we will reduce circuit board area to 1 DIN (German industrial standards)-size by pushing forward with the unification of memories and the integration of peripheral functions. This supports reduction of system design work by simplifying the circuit board.

MIDDLEWARE FOR THE SUPPORT OF AUTOMOTIVE INFORMATION SERVICES

Middleware for the Implementation of Car Multimedia Services

As a new development in car navigation, there is an increasing demand from automobile manufacturers for a "car multimedia system" for configuring conventional ITS information systems. The implementation of a car multimedia system or CIS (car information system) is expected to depend greatly on middleware that runs on general-purpose microprocessors. The need for middleware includes maintenance of the quality of information service (image compression and music compression for example) and advanced HMI functions (voice, security, etc.). The issues for middleware include:
(1) high-speed processing,
(2) reduced memory use,
(3) low power consumption,
(4) media processing components, and
(5) compatibility with various operating systems (see Fig. 4).

Middleware holds great significance for the implementation of the three requisite elements of car multimedia: comfort, information services and safety.

The voice processing middleware and sound (music) middleware that Hitachi is developing for implementation of an advanced function HMI are described in the following sections.

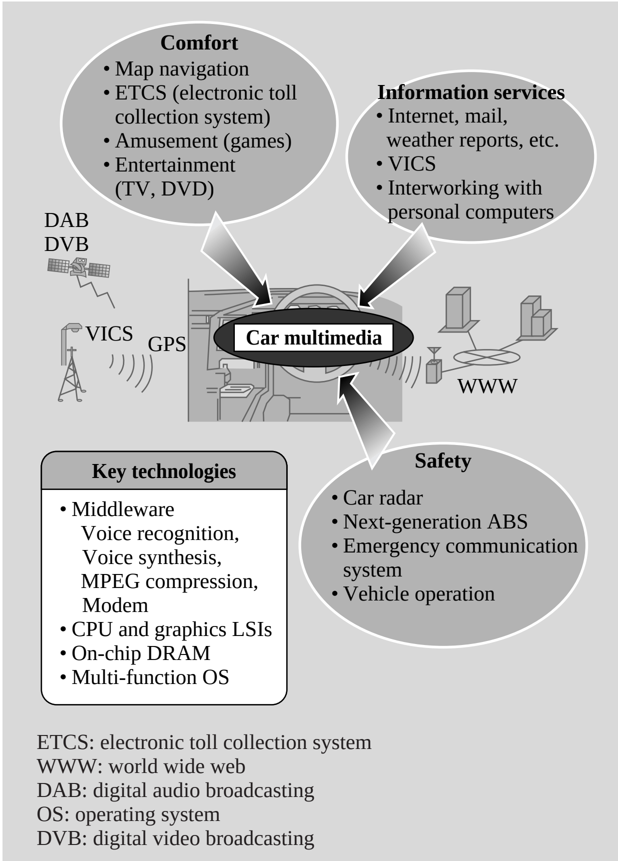

Fig. 4—Future Car Multimedia System.
Car multimedia involves three necessary elements: comfort, information services and safety. The key technologies for realizing those elements are middleware for general-purpose microprocessors, high-speed, high-quality graphics, microprocessors with memory integration, and a multifunction real-time OS.

Voice Processing Middleware[2)–4)]

Conventional voice processing middleware consists of middleware for single-word voice recognition with a limited vocabulary of a few thousand words and middleware for the voice synthesis of fixed expressions, both of which run on Hitachi's SH-3 (80 MHz) and SH-4 (260 MHz) processors. The recognition method employs HMMs (hidden Markov models) of phoneme fragments, a method which incorporates noise countermeasures that are robust against changes in the acoustic environment. The specifications are for the task of place-name word recognition in the domain of car navigation. Now, we have developed the "word spotting" method to achieve large-vocabulary place-name voice recognition and keyword recognition.
(1) Large-vocabulary place-name recognition (continuous-word voice recognition) method

This is middleware for the recognition of tens of thousands of place-names and building names that operates with efficient use of memory. Beam search was introduced for the purposes of structuring and developing the recognition dictionary, with the result that a search on 110,000 place-names can be processed in less than five seconds with 3 Mbytes of memory (1/4 of the conventional amount). Furthermore, the system can also handle superfluous utterances such as “well, uh” or possessive particles.

(2) Word spotting method

The recognition of only target keywords in continuous speech is important in achieving smooth dialog between humans and machines. As a first step, we developed a toy application of the word spotting method for recognizing a vocabulary of 100 words in speech that contains two or three keywords.

Sound (Music) and Image Middleware[5)]

(1) Sound middleware

There is a demand for services that involve music compressed with MP3 (MPEG-1 audio layer 3) or AAC (advanced audio coding) in a mobile environment. For that purpose, we developed an MP3 decoding library, an AAC decoding library and an AAC encoding library. All of those are processed by the SH-4 and the SH3-DSP with a CPU load of 30 to 40 MHz and a maximum RAM (random access memory) capacity of 45 kbytes.

(2) Voice compression and decompression middleware

The lineup being developed for this middleware ranges from the G.711 (A/μ-law voice compression and decompression) to the G.729A (voice compression and decompression LC/CS-ACELP), the G.165 (line echo canceller) and the G.167 (sound echo canceller).

(3) MPEG-4 video compression

Hitachi has middleware products for MPEG-4 (Moving Picture Experts Group 4) video compression as well as the JPEG (Joint Photographic Experts Group) still image compression that is used in digital still cameras. The popularity of music and video distribution services is expected to rapidly increase for automotive equipment as well as for mobile terminals. Therefore, we are responding to the need for middleware products.

REFERENCE PLATFORM

A Platform that Facilitates Construction of New Models

In addition to semiconductor products for users who intend to construct automotive information systems, Hitachi is also providing a reference platform that provides various kinds of elemental technology. This platform is described below:

The life model of the reference platform is illustrated in Fig. 5. The platform for CIS use consists of a reference board that serves as the foundation and elemental technologies that are useful in system development, such as debugging tools, a general-purpose OS driver library, middleware, application software, etc. The user can do preliminary development of application software on this reference board and also use it as a reference for creating a prototype, thus shortening the development time. Because the current products being used by the user have the same interface specifications as the board, it has the benefit of easy porting even when new models are constructed. On the other hand, even within Hitachi itself various types of next-generation technology are being developed on the reference board to realize system development. The results obtained here can be fed back into the development of the next generation of semiconductor devices and to platform development, while meeting

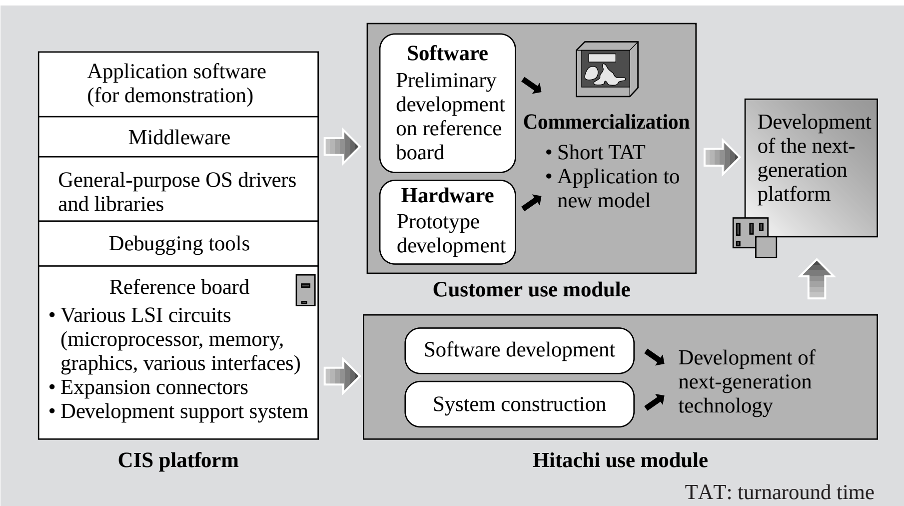

Fig. 5—Platform Life Model.
As a result of increased system sophistication and higher LSI integration scales, reduction of the amount of work involved in software development has become an issue. That means that the importance of the reference platform is steadily increasing.

user needs at the same time. From the fact that new models of automotive information systems are developed every one to two years, platform development is matched to the user's development cycle and phase.

Hitachi's Key Technology for Automotive Systems

Communication outside the vehicle, LAN connection within the vehicle and the HMI will be important in future automotive information systems (see Fig. 6). For communication outside the vehicle, reception of satellite and terrestrial digital broadcasting is needed in addition to cell phone connections.

For the intra-vehicle LAN connections, a multimedia system LAN such as MOST is required for the connection of added units such as DVD players. Also, the display of fuel efficiency information and failure diagnosis information or door lock control, etc. requires connection to a control LAN, of which CAN is a typical example.

For the HMI, a high-resolution LCD (liquid crystal display) capable of 3D graphics is required. The key technologies of the automotive information platform for supporting development of the customer's automotive information system, and making development in a short period of time possible are explained in the following sections.

(1) Network expandability

Connectivity with the LANs and buses of currently used multimedia systems and control systems is a matter of course, but expandability to be able to quickly cope with new technology that will appear in the future must also be maintained for the automotive information platform. Providing the platform with PCI slots and SH microprocessor bus slots makes it possible to offer new technology solutions by means of expansion cards.

(2) Graphics drivers

As an effect of the increasingly advanced functions required for automotive information systems, the merits of using a general-purpose OS in the construction of those systems have grown large. One such OS is Windows*1 CE, and particularly Windows Automotive, which is designed for the automobile environment.

Windows CE comes standard with a file system and other such functions for multimedia applications, so it is being employed by users who wish to shorten the development period. Hitachi immediately took on the task of developing an automotive information system platform for Windows Automotive. In particular, we have proceeded with development by giving attention to graphics technology, a basic function in the automotive information system, and one that continues to develop even now. To improve the performance of the map drawing function that runs on Windows CE, it is necessary to create a driver library for Hitachi's 2D graphics accelerators of the automotive information system that is optimized for Windows CE.

In addition to developing a graphics display library*2 that is specified in Windows Automotive for the Q2SD graphics display chip (one of the 2D graphics accelerators), Hitachi has also developed a display driver for the Q2SD that is optimized for high speed. As a result, a drawing speed that is upto about 30 times as fast as the Windows CE standard GDI is obtained.

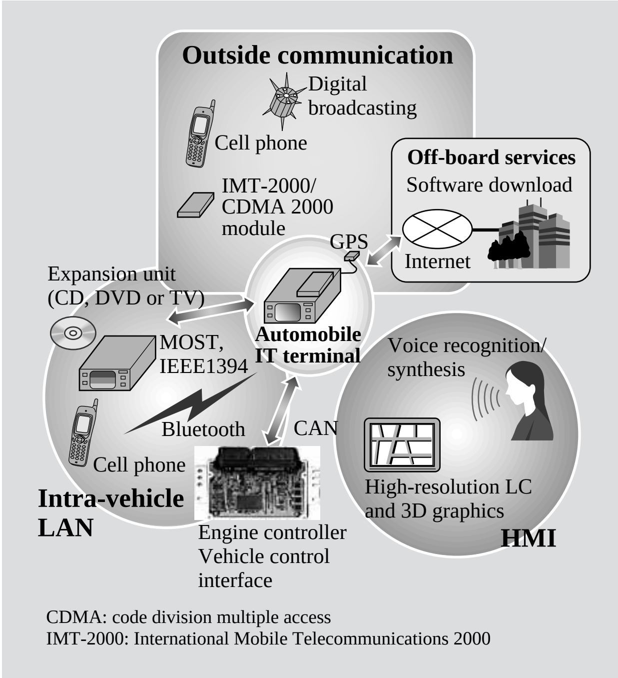

Fig. 6—Configuration of the Next Automotive Information System.
Communication outside the vehicle, intra-vehicle LAN connection and HMI will be important in the next automotive information system. The automotive information platform provides supporting technologies for the development of these functions.

*1 Windows is a registered trademark of Microsoft Corp. in the U.S. and other countries.

*2 A subset drawing library compatible with GDI (graphics device interface) and its calling instructions. It was created mainly for high-speed drawing of maps and has been optimized to fully exploit the performance of graphic LSIs.

CONCLUSIONS

We have described IP (Internet Protocol) products for an ITS automotive information platform, including a high-speed processor, communication protocols, codecs, and a voice interface, as well as a system development environment.

Hitachi offers a line-up of products from control and information system microprocessors based on semiconductor technology to hardware and software interface and middleware products for communication, voice/music, and video/graphics. In the future, too, we will continue with the development of the automotive information systems that will be indispensable in the advanced traffic system age.

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