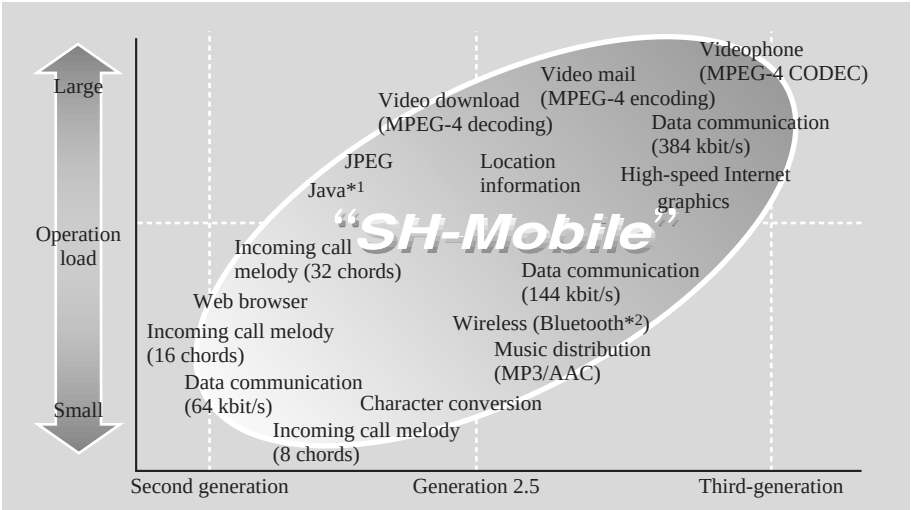
“SH-Mobile” LSIs for Cell Phones

Toshinobu Kanai
Hiroshi Yagi
Junichi Nishimoto
Ikuya Kawasaki

OVERVIEW: With the increasing number of functions performed by cell phones, processors are faced with demand for advanced multimedia processing capabilities. Coping with services that are offered by third-generation cell phones, such as videophone and video distribution, is difficult for the CPUs of the base band LSI chips of conventional cell phones. That points to the need for an application processor to strengthen multimedia processing. Furthermore, the increased software development work needed to cope with this multifunctionality is also becoming a problem for system development. Hitachi has developed the SH-Mobile Series RISC microprocessors to strengthen multimedia processing performance and the power conservation function for cell phones with advanced functions. The SH-Mobile Series answers the needs for advanced system functionality and shorter development time by providing basic cell-phone middleware and an application development platform together with the LSI. Furthermore, we are expanding the product line-up to cope with diversification of specifications.

INTRODUCTION

THERE has been steady progress in diversification of cell phone services over time, beginning with the first-generation analog systems, passing through the second-generation digital systems, and on to the inception of true third-generation services in 2001, with international roaming and high-speed data communication. The first and second generation cell phones mainly featured voice services, e-mail and web browsing services and incoming call melodies. At the stage of transition to the third generation, however, functions for color liquid crystal display (LCD) screens, reception of still and moving pictures, audio playback, and application programs written in Java or



MPEG-4: Moving Pictures Experts Group-4
JPEG: Joint Photographic Experts Group
MP3: MPEG-1 audio layer 3
AAC: adaptive audio coding
CODEC: coder-decoder

*1: Java and all Java related trademarks and logos are registered trademarks of Sun Microsystems, Inc. in the United States and other countries.
*2: Bluetooth is a trademark of Bluetooth SIG, Inc. of the United States. Hitachi, Ltd. uses this under a license contract.

Fig. 1—Applications Required for Cell Phones.
This shows the change in applications by cell phone generation. Beginning with generation 2.5 cell phones, an application processor that has advanced functions is required for multimedia processing, such as audio, still images and video.

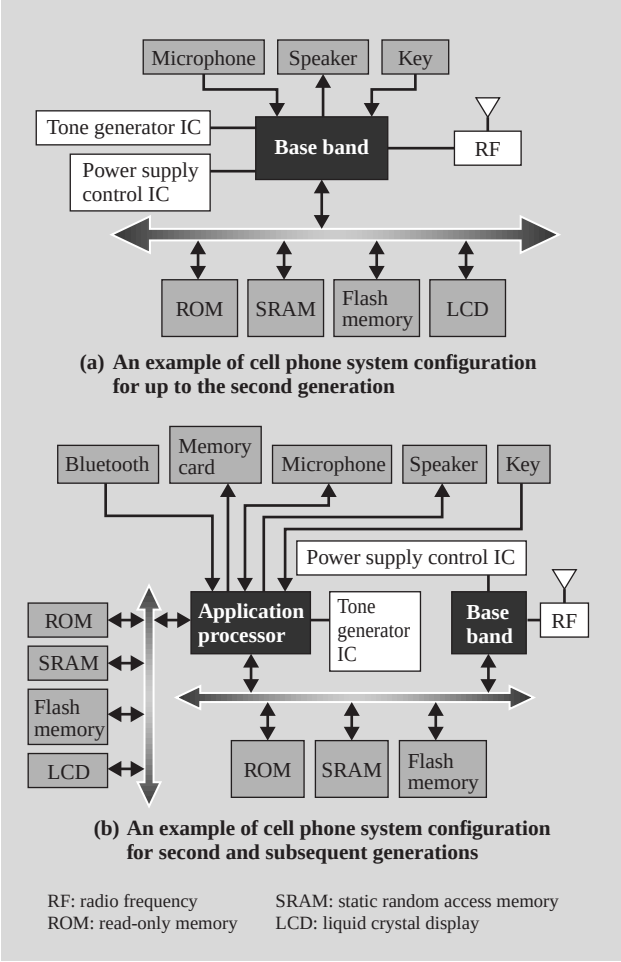


Fig. 2—Examples of Cell Phone System Configuration.
The configuration for up to the second generation, shown in (a), assigns all of the processing for the various applications as well as the telephone functions to the base band LSI. The system configuration shown in (b) adds a second processor, an application processor, which makes various kinds of processing possible.

other such languages are being added as what could be called generation 2.5. For the third-generation, video distribution by means of MPEG-4 (Moving Pictures Experts Group-4), high performance Java, videophone, and other such new services that make use of the high-speed data communication feature are being introduced (see Fig. 1).

These new applications require the processing performance of advanced processors, so it is difficult to perform all of the processing with the CPUs (central processing unit) that conventional base band processors have. That has prompted a conspicuous movement to reconsider the configuration of the cell phone system and supplement the base band processor with a new CPU for performing application processing. In response to that call, Hitachi is bringing to fruition the SH-Mobile Series of LSI chips, which are designed as application processors for cell phones.

Here, we describe the performance, features and future development of the SH-Mobile Series.

SH-MOBILE SERIES APPLICATION PROCESSORS FOR CELL PHONES

An example of the system configuration of cell phone systems up to the second generation is presented in Fig. 2 (a); an example of later system configurations is shown in (b) of the same figure. In systems up to the second generation, all of the processing for audio, LCD control, key control, RF (radio frequency) control and other such functions is done by the base band LSI. Although the application processing is beginning to be dealt with by increasing the speed and expanding the functionality of the base band LSI, the difficulty of improving the performance of the base band LSI in a single step and the increase in application software development work that will come with future advances in system functionality have been pointed out as problems.

On the other hand, the second generation and subsequent cell phone systems of Fig. 2 (b) comprise two CPUs, a base band LSI and an application processor (AP). The base band LSI handles the telephone functions and the AP handles other applications, including e-mail, Java, MPEG-4, music playback, key control and LCD control. With that configuration, the application processing that would be a large burden on the base band LSI is assigned to the AP. Furthermore, by introducing a configuration in which power to the AP can be cut off when an application is not being used, it is possible to avert both the increase in load on the base band LSI required for normal operation and the increase in overall system power consumption.

The system configuration for the SH-Mobile1 SH7290, a representative product of the SH-Mobile Series that was developed to serve as application processors for cell phones, is shown in Fig. 3. The SH-Mobile1 is an LSI chip that integrates, on a single chip, an SH3-DSP CPU core that has a maximum operating frequency of 133 MHz, a 16-kbyte X/Y memory (XY-RAM) for the DSP (digital signal processor), a 32-kbyte cache memory, a 128-kbyte user memory (URAM) and the various peripheral functions required by a cell phone system. The performance of this processor is equivalent to the processors that are already in use in hand-held computers and other such devices, and can fully cope with the ever increasing

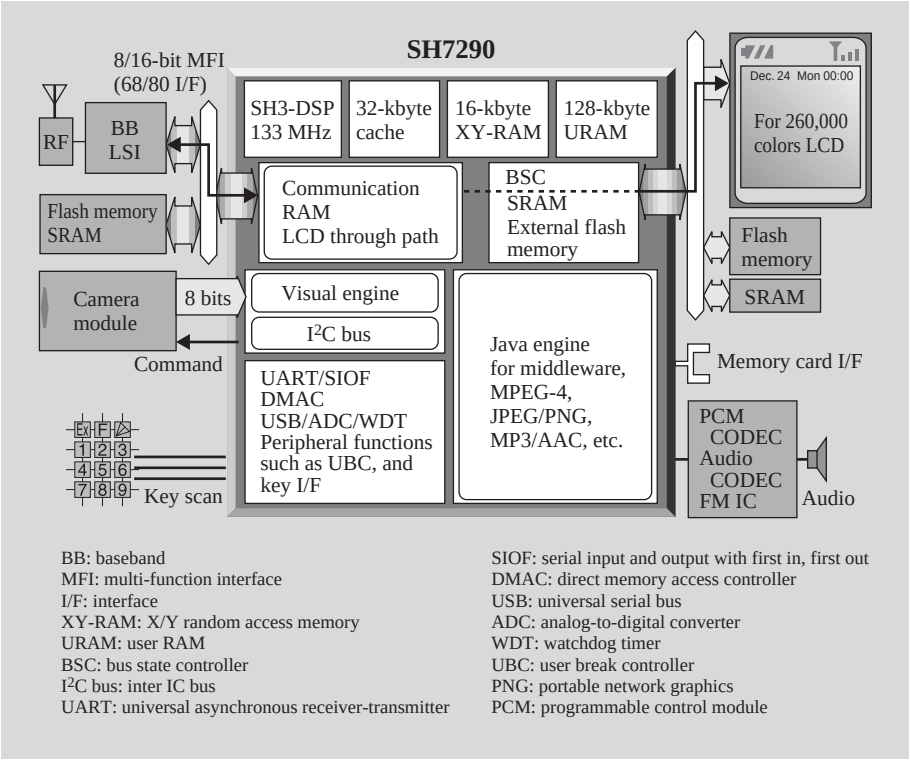


Fig. 3—SH-Mobile1 SH7290 Configuration and System Construction Example.
This shows the function blocks of the SH-Mobile1 SH7290 and an example of the construction of a cell phone system. The CPU and internal memory, as well as various peripheral functions are integrated on one chip.

types of multimedia processing. Furthermore, the burden of software development is reduced by providing abundant middleware and a development environment all together. The special features of the SH-Mobile Series are described in the following section.

BASIC SUPPORT TECHNOLOGY FOR THE SH-MOBILE SERIES

Method of Connection with the Base Band LSI

Existing cell phones use a wide variety of base band LSIs; the choice depends on the terminal manufacturer and the communication system. The SH-Mobile Series introduces a multi-function interface (MFI) function that ensures connectivity to various base band LSIs. The MFI has a parallel interface that can be switched between 8- and 16-bit widths and between 68 series and 80 series formats, making it possible to connect directly to the SRAM ports of nearly all base band LSIs (Fig. 3). SH-Mobile contains a dual-port (two-port) RAM that is called a "communication RAM" and is connected to the MFI and BSC (bus state controller). With the communication RAM as intermediary, data can be exchanged with both the base band LSI and SH-Mobile by the same procedure as is used when accessing ordinary SRAM. Also, the SH-Mobile, which is an AP, can operate in complete subordination to the base band LSI. That allows use to be made of the software assets that were developed for systems in which the conventional base band LSI is the master processor, with the aim of introducing an AP.

Power Conservation and the LCD Through Path

In the system shown in Fig. 3, the color LCD, which requires the transfer of large quantities of data, is connected to the system bus of the SH-Mobile, which has superior data transfer capability. That allows the display of video and other high-speed images. On the other hand, for the reduction in power consumption, the SH-Mobile Series introduces a power conservation mode called the "U-standby mode." In that mode, most of the power to the LSI is cut off at times when AP operation is not required, such as when the phone is in standby mode. However, it was anticipated that display to the LCD would not be possible during U-standby when the LCD was connected to the system bus. To solve that problem, an LCD through path that allows direct connection of the MFI and the system bus during U-standby was incorporated. The LCD can be controlled directly from the base band LSI during U-standby by using the LCD through path. During standby, only the base band LSI operates, just as in a conventional system, thus making it possible to realize a system in which the AP is invoked to do application processing only when it is necessary.

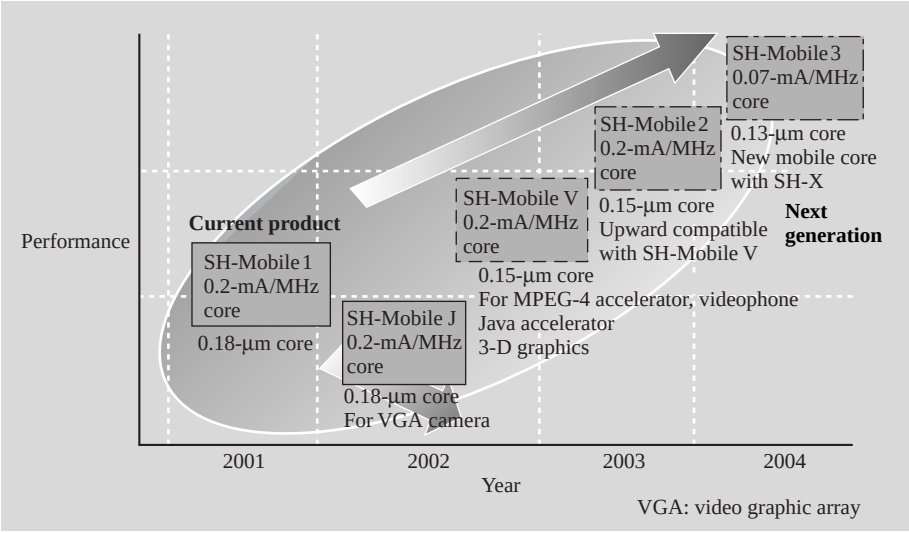


Fig. 4—SH-Mobile Series Product Road Map.
The product line-up is being supplemented to strengthen multimedia processing performance.

Visual Engine

One new service for cell phones that is gradually increasing is the terminal that is equipped with a camera. The SH-Mobile Series introduced a "visual engine," which connects directly to a camera module that combines a camera DSP with a sensing device, such as a CMOS (complementary metal-oxide semiconductor) sensor. The visual engine provides hardware processing for reading the captured image data and for format conversion. It has an I^2C bus interface for accessing an 8-bit data bus and the registers in the camera module. The SH-Mobile1 is capable of still and motion image processing up to CIF (common intermediate format) size. The image size for which processing is possible will probably increase with the development of new products for the line-up (see Fig. 4).

APPLICATION DEVELOPMENT ENVIRONMENT AND SOFTWARE SOLUTIONS

Solution Engine

For the SH-Mobile Series, a software platform that has the kind of configuration shown in Fig. 5 is provided. The core is the "solution engine," a development board for concentrating all of the SH-Mobile chip and peripheral devices that are required for a cell phones system, such as the LCD panel, CMOS camera module, key switch and various types of memory (see Fig. 6).

Middleware Support

The SH-Mobile development environment provides, in addition to the hardware drivers, an operating system (OS) such as "µITRON*," image processing such as for MPEG-4 and JPEG images, audio processing such as for MP3 and AAC formats,

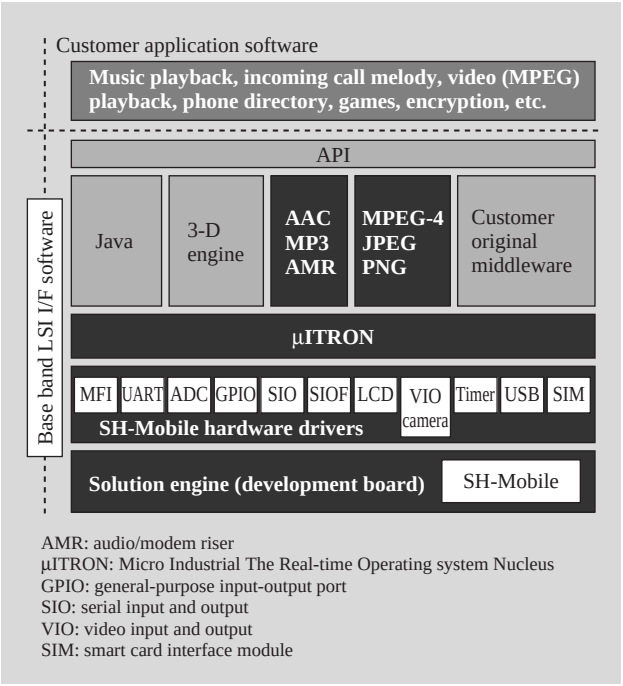


Fig. 5—Example of SH-Mobile Series Software Platform Configuration.
Hitachi and partner manufacturers provide customers with hardware (the Solution Engine), drivers, OS (µITRON), and various types of middleware in a single package, thus allowing the customer to concentrate on application development.

*: µITRON is the abbreviation for "Micro Industrial TRON." TRON is the abbreviation for "The Real-time Operating system Nucleus," real-time operating system specifications proposed by Professor Ken Sakamura of the University of Tokyo.

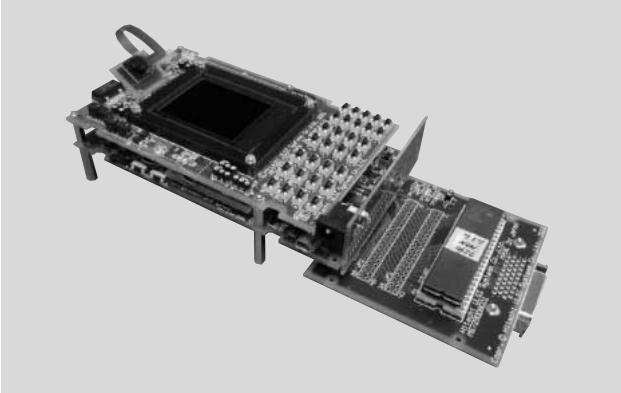


Fig. 6—External Appearance of the SH-Mobile1 SH7290 Solution Engine.
This development board concentrates various peripheral devices that are required for a cell phone system, such as an LCD panel, CMOS camera module, key switch and various types of memory devices.

and other middleware deemed essential for cell phones. Furthermore, with the cooperation of many partner manufacturers, it will be possible to implement even faster functions by means of a third-generation engine, embedded Java and other such improvements. We also plan to expand compatibility with other operating systems.

Embedded Java

To allow the implementation of diverse applications, the introduction of embedded Java for cell phones is also becoming common. When executing Java in cell phones, where it is difficult to increase the speed of access to external memory because of constraints in the mounting board design, the large capacity cache memory of the SH-Mobile processor (32 kbytes) is useful. Hitachi, in collaboration with partner manufacturers, is developing a Java engine that makes full use of that cache memory to achieve a processing speed that is 20 times that of conventional cell phones.

CONCLUSIONS

We have described the SH-Mobile Series application processors developed by Hitachi for use in cell phones.

The SH-Mobile Series first shipped in April of 2002 and has been in use by a number of cell phone terminal makers since that time.

In future development, we plan to further improve multimedia processing performance by increasing the resolution of the camera interface, introducing hardware acceleration for MPEG-4 and 3-D graphics, and so on. In particular, we will continue to introduce various kinds of new technology with the SH-Mobile 3 chip, which is in development targeting 2004, such as 0.13-µm process technology and the SH-X, a newly designed core for mobile devices.

REFERENCES

(1) T. Shindo, "Hitachi's Cell Phone Offensive," *Nikkei Electronics* **5**, pp.30-31 (May 2002) in Japanese.
(2) T. Yamada et al., "A 133MHz 170mW 10µA Standby Application Processor for 3G Cellular Phones," ISSCC Digest of Technical Papers, pp.370-474 (2002).
(3) T. Tsunoda et al., "Application Processor for 3G Cellular Phones," Proc. COOL Chips V, Vol. I, pp.102-111 (Apr. 2002).

ABOUT THE AUTHORS

Toshinobu Kanai
Joined Hitachi, Ltd. in 1998, and now works at the System Solution Business Unit of the Semiconductor & Integrated Circuits. He is currently engaged in the marketing of the SH-Mobile series and other microprocessors for cell phones. Mr. Kanai can be reached by e-mail at kanai-toshinobu@sic.hitachi.co.jp.

Hiroshi Yagi
Joined Hitachi ULSI Systems Co., Ltd. in 1991, and now works at the System Solution Business Unit of the Semiconductor & Integrated Circuits. He is currently engaged in the development of the SH-Mobile series and other microprocessors for cell phones. Mr. Yagi can be reached by e-mail at yagi-hiroshi@sic.hitachi.co.jp.

Junichi Nishimoto
Joined Hitachi, Ltd. in 1992, and now works at the Hardware and Software Technology Division of the Semiconductor & Integrated Circuits. He is currently engaged in the development of the SH3-DSP core. Mr. Nishimoto can be reached by e-mail at nishimoto-junichi@sic.hitachi.co.jp.

Ikuya Kawasaki
Joined Hitachi, Ltd. in 1982, and now works at the System Solution Business Unit of the Semiconductor & Integrated Circuits. He is currently engaged in the development and marketing of the SH-Mobile series and other microprocessors for cell phones. Mr. Kawasaki can be reached by e-mail at kawasaki-ikuya@sic.hitachi.co.jp.