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Special Reports

Cell －A New Paradigm for Computing

Steps toward the Future with Cell
SAITO Tomotaka

Design Concept of Cell Broadband Engines
HAYASHI Hiroo/ SAITO Mitsuo/MASUBUCHI Yoshio
Extremely high data and multimedia processing performance is demanded for next-generation applications ranging from digital home entertainment to distributed network computing. The Cell Broadband Engine (CBE) was developed to meet this demand. The CBE has many unique features, such as its heterogeneous multicore structure.
This paper describes the design concept of the CBE as well as its future road map.

Cell Broadband Engine Next-Generation Processor
KUROSAWA Yasuhiko/WATANABE Yukio/TAGO Haruyuki
The Cell Broadband Engine (CBE) is a heterogeneous multicore processor chip that incorporates Synergistic Processor Elements (SPEs) as high-performance multimedia processors and the PowerPC Processor Element (PPE) as a general-purpose processor core, connected to a high-speed input/output (I/O) and a high-speed memory system by a high-bandwidth internal bus called the Element Interconnect Bus (EIB). Cell broadband architecture is a scalable architecture that is optimized for parallel and distributed broadband computing environments.

SuperCompanionChip$_{TM}$ Making Optimal Use of Cell Broadband Engine
TAMAKI Shojiro / KUNIMI Masaki /SOMA Takahiro
Toshiba has developed the SuperCompanionChip$_{TM}$ (SCC) to make optimal use of the Cell Broadband Engine (CBE) and expand its applications to the audiovisual (AV) and network markets. The FlexIO interface (5 Gbytes/s (transmit) + 5 Gbytes/s (Receive)) was implemented in the SCC in order to communicate effectively with the CBE and realize high performance. The FlexIO bandwidth is shared equally between a hierarchical internal bus (2.66 Gbytes/s (transmit/receive)) and a memory interface (2.66 Gbytes/s (transmit/receive)). The memory interface was designed for the DDR2 interface, which has a dedicated direct memory access controller (DMAC) (2.66 Gbytes/s (transmit/receive)). Some internal bus interfaces have a quality of service (QoS) structure. The internal bus structure also enable to handle as real time processing (e.g., AV interface) and best effort processing (e.g., PC legacy IO) are distinguished.

Power Supply System for Cell Broadband Engine
TAKEI Hiroshi/TAKEMOTO Akihiko/YAMAGUCHI Daisuke
Toshiba has developed the TB6814FLG pulse width modulation (PWM) controller for 5 V input DC-DC converters and the TB7003FL multichip module (MCM) for installation in power devices operating at 1 MHz frequency. These technologies enable the optimal power supply system for Cell Broadband Engine to be constructed, securing high accuracy, rapid response, a compact structure, and high efficiency.

Overview of Cell Reference Set
UEMURA Goh/OMIZO Takashi/AWAZU Koichi
Mass production of the Cell processor chip set has begun. In order for this new LSI to penetrate and grow in the global market, it is essential to offer a platform that enables the development of software for the applicable hardware. In recent years, hardware and software development have become large in scale and increasingly complex. To make use of the features of Cell Broadband Engine so as to allow reuse for a prolonged period, it is necessary to involve third parties and service vendors and to expand software resources.

Configuration of Cell Reference Set Hardware
SATO Yuichi/NISHIDA Yoshihiro/NISHIBAYASHI Hiroshi/UNESAKI Tsutomu
The Cell reference set was developed to enable users who are investigating next-generation audiovisual (AV) platforms to easily and flexibly evaluate the Cell Broadband Engine (CBE), which has very high stream processing capability comparable to that of a supercomputer, and the SuperCompanionChipTM (SCC), which accommodates as many as 10 interfaces.

The Cell reference set hardware provides a reference design to achieve stable operation for this new-generation processor, which requires a high-capacity core power supply and superhigh-speed multibit input-outputs (I/Os). It also has flexible expandability to utilize the various I/Os of the SCC, and is supplied with a dedicated chassis that incorporates a low-noise, highly efficient dedicated liquid cooling system.

Configuration of Cell Reference Set Software
AMEMIYA Jiro/MIZUNO Satoshi/NOZUE Hiroshi/ARIMA Yugo
Toshiba provides the Cell reference set and its software. The software allows users to make best use of the Cell Broadband Engine (CBE). Using the functions of the CBE, the Hypervisor operating system (OS) "Beat" gives a virtual machine environment to each of multiple OSes running simultaneously. Beat virtualizes Synergistic Processor Elements (SPEs), which are one of the features of the CBE, enabling a programmer to use more SPEs than actually exist in the CBE. We have ported Lv2Linux and ITRON running on the virtual machine environment provided by Beat. Lv2Linux and ITRON can communicate with each other by the communication method between logical partitions, which is also provided by Beat, enabling cooperative operation between them. In addition to making flexible OS composition possible, as described above, the Cell reference set software also incorporates drivers for the SuperCompanionChipTM (SCC), which controls the various input-outputs (I/Os) of the reference set.
Cell reference set users can easily evaluate the CBE using this software, allowing them to start software development at an early stage.

Runtime Environment for Cell Programs
MAEDA Seiji /SATO Kiyoko/KAWAKAMI Ken
In order to fully exploit the performance of the Cell Broadband Engine (CBE), it is essential to efficiently utilize the Synergistic Processor Elements (SPEs). However, simply supplying complex hardware to software engineers makes software development complicated, and realizing parallel and real-time processing becomes very difficult.
To solve this issue, Toshiba has developed the SPE runtime environment, which supports software development using multiple SPEs. By offering a programming model developed for potential use cases, along with SPE resource reservation and SPE overlay features, the SPE runtime environment enables programmers to easily implement parallel and concurrent processing, making the CBE applicable to various products.

Cell Software Development Environment
OSAWA Satoshi /UCHIKAWA Takayuki/TAKANO Hidetaka
Toshiba has developed an Eclipse-based integrated development environment, a PPE/SPE (PowerPC Processor Element/Synergistic Processor Element) seamless debugger, and a performance monitor to make up our Cell software development environment. The debugger, named CBE-GDB (Cell Broadband Engine-GNU debugger), is based on the GNU debugger and has been extended to enable the debugging of PPE and SPE programs simultaneously. We have developed a Cell-compatible C/C++ development tool (CDT) named CBE-CDT as an extended plug-in for Eclipse, which makes it possible to use a graphical user interface to debug PPE/SPE programs with CBE-GDB. The performance monitor uses performance monitoring functions inside Cell to enable the user to measure the number of instructions issued, the bandwidth of an internal bus, etc.

Cell Audiovisual Application
KOMORI Tatsuya/HARAGUCHI Takuma/SAKAI Ryuji
Applying the high-performance Cell Broadband Engine (CBE) and SuperCompanionChipTM (SCC), the Cell reference set allows audiovisual (AV) applications having intensive processing power requirements to be built that run solely on software solutions. Such applications were previously difficult to realize without hardware assistance.
In order to demonstrate the high performance of the CBE, Toshiba has developed AV application software that implements real-time multistream processing. This software can simultaneously process six streams of high-definition (HD) contents or 30 streams of standard definition (SD) contents. By fully utilizing the operating system, AV application framework, and various middleware bundled in the Cell reference set, which were prepared for the development of this type of application software, the development term can be shortened.

Cell Image Processing Applications
KONDOH Nobuhiro/HIWADA Kazuhiro/TANIGUCHI Yasuhiro/KAZAMA Hisashi
One of the key points to fully utilize the high performance of the Cell Broadband Engine (CBE) is to effectively use the eight Synergistic Processor Elements (SPEs) in a chip. To demonstrate the high performance of the CBE, Toshiba has developed sample applications that mainly deal with image data processing or computer graphics, based on the Cell reference set. We have built applications for makeup simulation, hair-styling simulation, gesture recognition, and identification by face recognition, thereby confirming the excellent performance of the CBE.

Feature Articles

Catalysts and Electrodes for Direct Methanol Fuel Cells
MEI Wu/NAKANO Yoshihiko
Direct methanol fuel cells (DMFCs) have been attracting great attention in recent years for their potential as clean, portable power sources. High-performance electrodes are crucial for the commercialization of DMFCs.
Toshiba has developed Pt-Fe-N catalysts and carbon nanofiber (CNF) cathode electrodes to meet this requirement. Higher oxygen reduction activity was obtained with the Pt-Fe-N catalysts than with conventional Pt catalysts, with no obvious degradation. CNFs were explored to modify the electrode structure. Excellent DMFC performance at low air-feeding rates was realized by using highly dispersed Pt nanoparticles supported on the CNFs (Pt/CNFs) as cathode catalysts.

Green Procurement Management Model Demonstration Project in Thailand
INAMI Osamu/NODA Hideki/SATO Yuzo
At the request of the Ministry of Economy, Trade and Industry (METI), the Japan External Trade Organization (JETRO) is carrying out the Pilot Demonstration Project Program to Improve Trade and Investment Environments. The aim of this project is to contribute to the promotion of economic partnerships in East Asia through the establishment of economic systems and institutions that will benefit each country.
The Green Procurement Management Model Demonstration Project in Thailand promoted by Toshiba was accepted as one of the proposals adopted in fiscal year 2005 for this project. Toshiba organized a project team with the cooperation of the Electrical and Electronics Institute (EEI), and implemented the project over a period of approximately six months. For this project, we added multilingual support functions in Japanese, English, and Thai to the Eco Club green procurement management software on sale in Japan. We also guided the data management process based on the Japan Green Procurement Survey Standardization Initiative (JGPSSI) and indicated the next action items for practical implementation in Thailand. This project has made it possible to increase the market for green procurement software in Thailand.

Novel System for Inspection of Piping Corrosion and Defects
HAMADA Tomohiro/KATAYAMA Masahiro
Toshiba has developed a novel wall-thickness inspection system for piping that employs a color image intensifier, UltimageTM, and a 3D ultrasonic inspection system, MatrixeyeTM. The UltimageTM system uses X-rays and gamma rays in combination to measure wall thickness without the need to remove thermal insulation. The MatrixeyeTM system uses flaw-detecting ultrasonic devices arrayed linearly or in a plane to rapidly identify corrosion and erosion defects on inside surfaces. Inspections are therefore easy to perform and the results are obtained without delay, greatly contributing to the efficiency of operations.

Development of Applications for High-Strength Reaction-Sintered Silicon Carbide
SUYAMA Shoko/ITOH Yoshiyasu
High-strength reaction-sintered silicon carbide (SiC), which was developed by Toshiba, has the world's highest strength exceeding 1,000 MPa. Its use has been steadily expanding in various energy and industrial applications, such as for hot parts and wear-resistant parts, due to its superior environmental resistance, high thermal resistance, high wear resistance, high stiffness, high thermal conductivity, low thermal expansion, and low density. It has also been attracting attention as an eco-friendly ceramic from the viewpoints of its low sintering temperature and near-net shape. In addition, it has been studied for application to heat exchanger parts for hydrogen production systems, and to mirror substrates for space optics, etc.
This paper describes the expanding range of applications for high-strength reaction-sintered SiC.

Frontiers of Research & Development

Advanced Simulation Technology Supporting Development of High-Performance Hydraulic