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MICROPROCESSOR REPORT

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Cell Processor Isn't Just for Games

Innovative Chip Is Best High-Performance Embedded Processor of 2005

By Tom R. Halfhill {1/30/06-01}

Deciding on our *MPR* Analysts' Choice Award for Best High-Performance Embedded Processor of 2005 wasn't easy. We evaluated several strong candidates before picking our winner: the Cell Broadband Engine, jointly designed by the STI alliance: Sony, Toshiba, and IBM Microelectronics.

The Cell BE is destined for Sony's next-generation home videogame console, the PlayStation 3, scheduled for release later this year. However, unlike the processors that IBM designed for Sony's competitors—unnamed CPUs buried inside the Microsoft Xbox 360 and Nintendo Revolution—the Cell BE is part of a grander scheme. Sony, Toshiba, and especially IBM are promoting this radical multicore processor and future derivatives as popular number-crunching engines for everything from cellphones to supercomputers.

Their vision may seem overly optimistic, as we noted in an editorial last year. (See *MPR 2/28/05-01*, "Cutting Through Cell's Hype.") But it's not just a dog-and-pony show. Toshiba, a manufacturing partner in the Cell alliance, plans to use the chips in high-volume consumer-electronics products, such as high-definition TVs. Sony has similar plans.

Outside the STI alliance, three customers have adopted the Cell BE: Mercury Computer Systems, Raytheon, and Stanford University. Mercury is showing three products: a blade server, a rugged "computing appliance" for military systems, and a powerful workstation for scientific, technical, and industrial applications. Raytheon says it will use the Cell BE in missile systems, artillery shells, and radars. Stanford University is building a supercomputer for scientific computing. These impressive design wins prove that the Cell BE isn't only for fun and games.

Data Parallelism Is Cell's Strength

We chose the Cell BE as the best high-performance embedded processor of 2005 because of its innovative design and future potential. Note that *MPR* broadly defines an embedded processor as any chip not primarily intended to be a CPU for PCs, workstations, or servers. Although the Cell BE cuts across that definition—already, the chip is finding its way into workstations, servers, and supercomputers—it was designed primarily for what we consider an embedded system, the PlayStation 3.

At the nucleus of the Cell BE is a 64-bit processor core based on IBM's Power Architecture (more popularly known as PowerPC). This core is a two-way superscalar RISC processor with a deep 21-stage in-order pipeline. It's capable of reaching clock frequencies in the 4.0GHz range when fabricated in a 90nm CMOS process. (Sony will limit the clock speed to 3.2GHz in the PlayStation 3, probably to obtain better yields.)

The Power core is the Cell BE's control-plane processor—it can run a sophisticated operating system and supervise other tasks. Because the core is based on IBM's Power Architecture, the Cell BE can leverage some PowerPC software and tools, and it may benefit from outgrowths of the Power.org Consortium. (See *MPR 12/27/04-02*, "Bringing Power to the People.")

The real muscles in the Cell BE are the on-chip coprocessors, which IBM calls synergistic processor elements (SPE). These are SIMD vector engines with local memories and new instruction sets. Essentially, they are full

For More Information

For our analysis of the most important embedded-processor events of the past year, with links to dozens of relevant *MPR* articles, see *MPR 1/30/06-02*, "Embedded Processors Thrive in 2005." For more information about the Cell BE and related processors, see *MPR 2/14/05-01*, "Cell Moves Into the Limelight"; *MPR 1/3/05-01*, "New Patent Reveals Cell Secrets"; *MPR 2/28/05-01*, "Cutting Through Cell's Hype"; *MPR 10/31/05-01*, "IBM Speeds Xbox 360 to Market"; and *MPR 7/18/05-02*, "Powering Next-Gen Game Consoles."

CPUs in their own right. The control processor can assign tasks to the SPEs and let them run autonomously, checking back later for results. IBM's initial design packs eight SPEs on chip, but larger and smaller designs are possible to accommodate different applications and power envelopes. Tying everything together are cleverly crafted internal buses and external memory interfaces fast enough to keep the SPEs fed with data. (See *MPR 2/14/05-01*, "Cell Moves Into the Limelight.")

In addition, patents suggest that the Cell architecture is the foundation of a distributed software model that embodies clustering and grid computing as native concepts. Under this model, self-contained bundles of program code and data ("software cells") could roam in search of execution resources, whether those resources are on the same chip, in the same system, or in a different system anywhere in a network or on the Internet. IBM hasn't talked much about this concept, saying only that the Cell BE supports multiple programming models. (See *MPR 1/3/05-01*, "New Patent Reveals Cell Secrets.")

Even if the Cell BE accumulates no more design wins, the PlayStation 3 could drive sales to nearly 100 million units over the likely five-year lifespan of the console. That would make the Cell BE one of the most successful microprocessors in history.

Other Award Nominees Shine, Too

Other chips we considered for this year's award were Cavium Networks' Octeon NSP CN3860 network services processor, Freescale's MPC7448 general-purpose embedded processor, IBM's Xbox 360 videogame processor, IBM's BlueGene/L supercomputer processor, Philips Semiconductors' Nexperia PNX1700 media processor, and Raza Microelectronics' XLR network processor.

What impressed us about this year's candidates was their predilection for radical design. In the past, *MPR* has presented awards in a category we called "extreme architectures." Lately, the distinction between extreme architectures and mainstream architectures has been disappearing. Although the six chips listed above are based on conventional architectures (MIPS, PowerPC, and TriMedia), they implement those architectures in radical ways. Four of the six chips are multicore designs with as many as 16 processor cores, plus additional integration. The most conventional design in the group is Freescale's MPC7448, a 1.7GHz PowerPC single-core processor that set a new EEMBC-benchmark speed record.

Most nominees in this award category make the latest dual-core PC processors seem positively pedestrian in comparison. As we noted a year ago, embedded processors have emerged from obscurity to become the driving force of innovation in the semiconductor industry. ◇