Hitachi SH7750 Shines for Sega

First SH-4 Has 3D Geometry Extensions; Targeted for 0.25-Micron Process

by Jim Turley

Hitachi has pulled the wraps off the first chip in its SH-4 line: the SH7750, a specialized embedded processor that can accelerate 3D graphics. For just $40, the new processor is better at certain aspects of 3D geometry than Pentium II. Slated to begin general sampling in 1Q98, the SH7750 will make its splashiest debut in Sega's next-generation game console shortly before the end of 1998.

The SH7750 is the first part in the SH-4 generation; other, more integrated chips are expected to follow near the end of 1998 and into 1999. Following that, Hitachi and SGS-Thomson will collaborate on the SH-5 generation, slated to appear around 2001 (see MPR 12/29/97, p. 10).

Chip Bundles FPU, Caches, 3D, DRAM Control

As expected, the chip's SH-4 core will run at 200 MHz (see MPR 10/28/96, p. 32). To that core the SH7750 adds 8K/16K instruction/data caches, an integrated DRAM controller, four DMA channels, two serial channels, a real-time clock, and an MMU compatible with Windows CE. Half of the 16K data cache can be converted to RAM under software control. The data cache is updated using a write-through or write-back policy, selectable on a page-by-page basis.

As Figure 1 shows, the SH7750 includes an FPU—only the second SuperH chip to come so equipped. Unlike the FPU in the SH7718 (see MPR 10/27/97, p. 11), the FPU on the SH7750 handles both single- and double-precision IEEE-754 floating-point values.

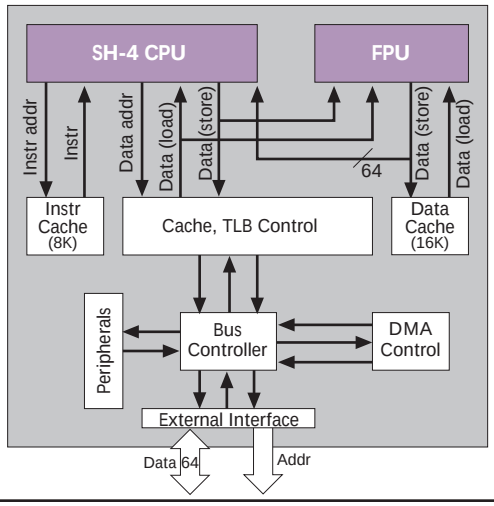

Figure 1. The SH7750 allows two-way superscalar execution between its integer and double-precision floating-point units. The several internal buses allow the chip to move up to 288 bits during FP geometry calculations.

Wider internal buses were needed for the larger FP values: they allow the SH7750 to shuttle as much as 288 bits of single-precision FP data into and out of the chip's remarkable vector-geometry unit on every cycle. The vector unit allows the SH7750 to complete a four-element floating-point inner-product calculation every cycle at 200 MHz—a feat no other microprocessor, embedded or otherwise, can match. Coupled with a graphics controller, this ability should provide outstanding 3D geometry performance.

Like Intel, Hitachi promotes the use of a host processor (in this case, an SH-4 chip) for geometry and a dedicated graphics accelerator for rendering. With the SH7750, Hitachi is aiming straight at the living room: television set-top boxes, Internet terminals, and, of course, video-game consoles.

Production Cycle Appears Compressed

Early samples of the SH7750 have been in the hands of certain "strategic customers," including Sega, since October. Those samples were built in a slower, 0.35-micron process; Hitachi is just now trickling out parts built with 0.25-micron technology. The chip's production schedule is only slightly behind Hitachi's initial projections: the company says it is on track to deliver production silicon in 3Q98. In 0.25-micron technology, the SH7750 measures 7.6×7.6 mm (58 mm^2), as the die photo in Figure 2 shows. The MDR Cost Model estimates the SH7750 costs about $20 to build.

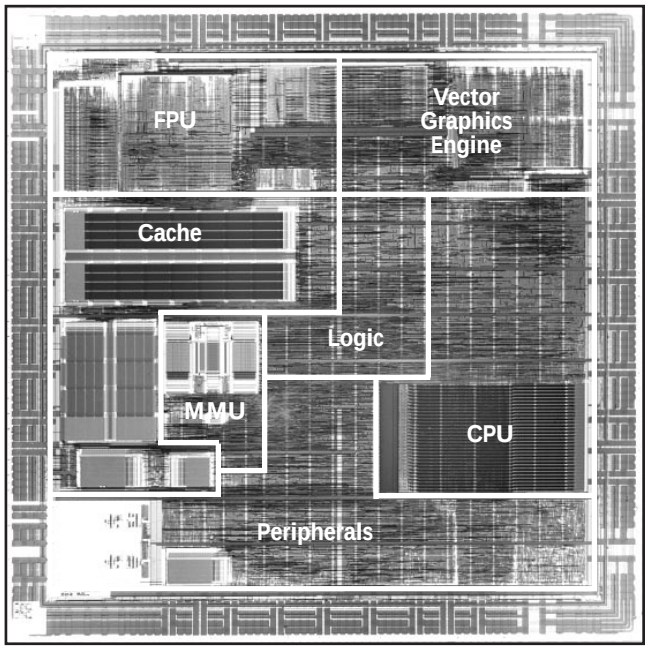

Figure 2. In Hitachi's 0.25-micron process, the SH7750 measures 7.6×7.6 mm and runs at 200 MHz.

Hitachi rushed out the early 0.35-micron parts so its customers could begin creating and testing software tools. They weren't much help to hardware developers at all. The early samples were significantly slower than the 0.25-micron parts, so bus timing couldn't be verified. The samples also ran at a lower voltage and consumed more power, so interface silicon couldn't be tested. It appears that, for Sega at least, a head start in developing software was the overriding concern.

Chip Comes With Memory Control, Power Modes

Never forgetting its heritage in microcontrollers, Hitachi designed in a number of space- and time-saving hardware features. The 64-bit DRAM controller is the most useful, handling either synchronous or EDO DRAMs with no additional glue logic. The chip multiplexes row/column addresses and handles refresh or self-refresh (for DRAMs with that capability).

The speed of the CPU, the bus interface, and the peripherals can all be dialed in through software. Divide ratios from 1:1 through 8:1 are selectable, up to a maximum of 200 MHz for the CPU, 100 MHz for the bus, and 50 MHz for the peripherals. With a 100-MHz external bus and 100-MHz synchronous DRAMs, the SH7750 can achieve 800 Mbytes/s of sustained memory bandwidth.

Like most 0.25-micron devices, the SH7750 subsists on two different power supplies: 1.8 V for the core and 3.3 V for the I/O ring. The production-level 0.25-micron part has not been characterized, but Hitachi anticipates it will typically draw 1.5 W at 200 MHz.

The chip will come in a 256-contact, low-profile plastic BGA that measures barely one inch on a side and less than one-tenth of an inch high. Although its DRAM interface is already completely glueless, Hitachi partner VLSI Technology is preparing a companion chip for the SH7750.

Programmers have access to three power-saving modes. Two are entered through the STBY instruction; the actual mode depends on the state of a particular control bit. The third "module standby" mode shuts off preselected peripherals while the CPU and other peripherals keep running. Disabled peripherals can't be reawakened automatically, but only by specifically enabling them again, making this feature useful for shutting off unused units temporarily to save power.

Price Is Attractive, But Chips Still 9 Months Away

As a general-purpose microprocessor, the SH7750 will compete with Digital's original StrongArm, the SA-110, and with embedded PowerPC EC603e chips just out from Motorola and IBM (see MPR 12/29/97, p. 10). As a high-end media processor or decompression engine, Hitachi's part is on a collision course with Digital's SA-1500 (see MPR 12/8/97, p. 12).

Even disregarding the SH7750's advantages in geometry processing, the chip's price/performance compares favorably with that of today's SA-110 and embedded PowerPCs. Compared with the SA-110's, the SH7750's top clock rate is a bit slower (200 MHz vs. 233 MHz) but the chip is two-way superscalar. Its 360-MIPS rating (based on Dhrystone 1.1) is fully 33% higher than the SA-110's. Hitachi's asking price is also 20% cheaper ($40 in 10,000-unit quantities) than Digital's and 10% cheaper than Motorola's.

It is not today's chips that the SH7750 will compete against, however. The EC603e is available now and the SA-110 has been shipping for nearly a year, versus projected 3Q98 production for the SH7750. By the time the Hitachi part is available, the SA-110 will almost certainly be shipping at faster speeds, probably 350–400 MHz. If Digital maintains its aggressive stance on pricing, a 350-MHz SA-110 could be the better choice for integer code.

In Hitachi's favor, the SH7750 has a full FPU, a built-in memory controller, and several valuable peripherals—a claim neither the PowerPC nor StrongArm chips can make. Although the SA-110 has a bigger instruction cache (16K vs. 8K), the SuperH chip has better code density than StrongArm, so the actual number of instructions each can cache is about the same.

Price & Availability

General samples of the SH7750 (Hitachi part number HD6417750BP200) are expected in 1Q98; production is scheduled for 3Q98. In 10,000-unit quantities, the part will be priced at $40. For more information contact Hitachi (Brisbane, Calif.) at 800.285.1601, extension 27, or access the Web at *www.hitachi.com/semiconductor.*

A Simpler Approach to Media Processing

Integer performance, however, is not the SH7750's most valuable asset. For video processing, the chip competes with another Digital device, the SA-1500. Both have lots of extra on-chip logic to help the CPU with media processing. The SA-1500's attached media processor (AMP) is considerably more complex than the vector unit Hitachi added to its part. The AMP doesn't make the SA-1500 appreciably larger than the SH7750 (die sizes are within 5% of each other), but it does make the SA-1500 more complex.

The SA-1500's bicephalic nature makes it much harder to program; the SH7750 has just a single CPU and a single instruction set. In Digital's favor, the attached media processor in the SA-1500 is more flexible, capable of decompressing MPEG-2 video streams one moment and emulating a bank of 10–15 modems the next. The AMP, on the other hand, is not as well equipped to do 3D geometry as the SH7750 is, and that is Hitachi's advantage in its intended markets: set-tops and games.

Production schedules for the two chips are similar, with Digital claiming a slight edge if both firms stay on track. The Massachusetts company hasn't announced a price for its SA-1500, but to be competitive with Hitachi, the part can't be priced much more than about $40.

Sega 64 Nearing Completion

Sega's next-generation video-game console system, code-named Dural, is reportedly sampling to software developers and is slated for commercial release in 3Q98 in Japan. It should hit U.S. shores before Christmas 1998, just in time to help Sega rebuild its tattered business in North America.

Dural, which is likely to be marketed as the Sega 64, will include 3D graphics acceleration based on NEC's PowerVR family (see MPR 7/14/97, p. 5). The system is also expected to include a CD-ROM drive, an ARM-based Yamaha sound processor, several megabytes of DRAM, and a built-in modem (emulated by the SH7750 processor) for multiplayer gaming and Internet connectivity. The handheld controllers may contain their own LCD displays and nonvolatile memories.

Unlike Saturn, which has four 32-bit CPUs (see MPR 5/30/95, p. 15), Dural will likely be a single-processor system. Saturn's multiheaded monster proved to be a monster headache for game programmers, who were unaccustomed to the arcane complexities of symmetric multiprocessing.

Dural is also expected to run Microsoft's Windows CE operating system, which is already running on SH-3 chips. Support for the Win32 and DirectX APIs will allow programmers to more easily port game titles from Dural to standard PCs and vice versa. This makes Dural more attractive to developers than a proprietary game platform, opening the door to PC software sales.

The relative popularity of video-game platforms is reversed between Japan and North America. Although Saturn sales in the U.S. are well behind those of Sony's PlayStation and the Nintendo 64, the Sega platform sells quite well in Japan. The Nintendo 64, conversely, ranks last in sales of game consoles in the Far East. Consequently, the PlayStation enjoys the best overall sales worldwide.

With Dural, Sega is poised to make a comeback in North America in late 1998. With Dural's improved graphics, better software (because of Dural's simpler programming model), and new software portability between consoles and PCs, Sega hopes to use its new system to build a lucrative software business as it heads into 1999.

Hitachi rates the SH7750 at 1.5 W (typical) at 200 MHz; Digital says only that the SA-1500 uses 2.5 W (worst case) at 300 MHz. Allowing for their differences in measurement conditions, the two chips should consume power at roughly equivalent rates. For set-top boxes and line-powered games, absolute power consumption is not particularly relevant as long as the unit doesn't need a fan.

PDA Versions Possible in 1999

At more than a watt, the SH7750 is not suitable for PDAs or handheld PCs, another area where SuperH has had measurable success. It's possible that some future SH-4 parts might be more attractive, however. Lowering the clock rate from 200 MHz to, say, 100 MHz might allow Hitachi to drop the core voltage of the part from 1.8 V to nearly 1 V. That, in turn, would slash power consumption to just a few hundred milliwatts—well within the range of portable devices. Given that the SH7750 itself isn't due for another nine months, such a low-power variation may not appear until 1999.

In the meantime, Hitachi's SH-3 family (including the SH7702, '08, and '18) will probably rise to meet the demand. A 100-MHz SH7708 is just now coming on-line; a shrink to Hitachi's 0.35-micron process could easily boost that speed by another 50% while keeping power usage about the same.

Performance parity may come by 1998, but the SH-3 family should live on in the face of newer and faster SH-4 chips. The latter's floating-point unit, geometry functions, and superscalar core take their toll in terms of die area, cost, and power consumption. For today's and tomorrow's handheld items, these aren't features worth paying for. The SH-3 generation will continue to satisfy designers of computer-style systems (with or without floating point), while the SH-4 meets the needs of gamers and media moguls.

SH7750 Well Suited to Video Applications

If the target application calls for image massaging and little else, Hitachi has the advantage over Digital because of the SH7750's simpler programming model and better code density. The SH7750 also has a clear advantage in 3D graphics due to its specialized geometry-acceleration instructions. For Sega, these are worth as much as the rest of the chip.

Outside of the high-stakes world of video gaming, the SH7750 should find homes in other applications that value geometry processing. A television set-top box with deluxe menus and overlays based on the SH7750 (or another SH-4 device) might become a compelling item. Internet terminals are less certain—the part is fast enough to handle HTML and/or Java successfully, but except for occasional VRML pages, its geometry processing would go to waste.

The same is true for video phones, which need to compress and decompress images in real-time. The SH7750 would be better equipped for this task than most 32-bit CPUs but would lag the SA-1500 by a considerable margin.

It will be more than a year before anyone can tell, but if Sega's next game console is successful, other applications for the SH7750 won't be as essential. (Of course, additional applications never hurt; NEC and Hitachi have both had considerable success outside of Nintendo and Sega.) Game consoles have almost single-handedly made MIPS and SuperH the two best-selling 32-bit RISCs in a very short time. Hitachi has successfully escaped Sonic's shadow by selling SuperH into other applications, but the company wouldn't mind repeating that particular success again in 1998. M