VOLUME 11, NUMBER 3
MARCH 10, 1997

MICROPROCESSOR REPORT

THE INSIDERS' GUIDE TO MICROPROCESSOR HARDWARE

MediaGX Targets Low-Cost PCs

Compaq First to Use Cyrix's Integrated P133-Class Processor

by Linley Gwennap

Instead of simply offering a chip that does everything a Pentium does at a lower price, Cyrix has taken the next step by serving up the MediaGX, a chip that does more than any Intel processor. The new device delivers Pentium-class performance and software compatibility while adding an integrated memory controller, graphics accelerator, and PCI interface. The result is an innovative product that significantly reduces the cost of a PC without compromising performance. And Cyrix didn't forget the part about lower prices: even with these improvements, the 133-MHz MediaGX costs less than any of Intel's Pentium processors.

The new product was originally disclosed as the 5gx86 at the Microprocessor Forum in 1995 *(see* **091403.PDF***)*, and Cyrix had hoped it would be in systems by the middle of last year. Atypically, the delays were not in the CPU itself but in building the infrastructure to support it. With its unique pinout and system architecture, the MediaGX re-quired new motherboard designs and new device drivers. More important, Cyrix needed to convince PC makers that the value of the integrated design justified moving away from the comfort of Pentium pin-compatibility, a missionary task that took months.

This time and effort produced a big design win, in fact, the biggest win possible: Compaq, the world's number-one PC maker, is using the MediaGX in a low-end Presario system aimed at consumers. The new Presario 2100 realizes the potential of the Cyrix chip. The system has mainstream features—such as Pentium-133 performance, 24M of EDO memory, a 2G hard drive, an 8× CD-ROM, and a 33.6-kbps modem—but carries a suggested retail price of just $995, or $1,245 with a monitor.

Although Compaq is the first to market with a MediaGX system, several smaller desktop PC makers will follow suit in the next few months. The new chip also has advantages for notebook PCs, some of which will soon sport the new chip. Cyrix plans to aggressively increase the clock speed of the MediaGX over time, maintaining its competitiveness.

System Integration Boosts Performance

Conceptually, the MediaGX is similar to other processors with integrated system logic, including Sun's MicroSparc family, HP's PA-7x00LC family, and even Intel's 486SL, although Cyrix is the first to bring graphics onto the chip. In contrast to the poorly implemented 486SL, the MediaGX, like the aforementioned RISC chips, is an integrated design in every sense of the word, as its architects took advantage of the tight coupling between the CPU and the system logic to improve performance.

As Figure 1 shows, the MediaGX combines the scalar 5x86 CPU core *(see* **090901.PDF***)* with an on-chip DRAM controller, graphics accelerator, and PCI bus interface. By eliminating the overhead of tag lookups and synchronization to an external 66-MHz bus, the MediaGX's DRAM controller can read the critical first word from memory in six CPU cycles on a page hit, exactly the number of cycles it takes a 133-MHz Pentium to access its L2 cache. This speed essentially eliminates the need for an external cache in MediaGX systems.

Of course, the MediaGX takes longer to access DRAM

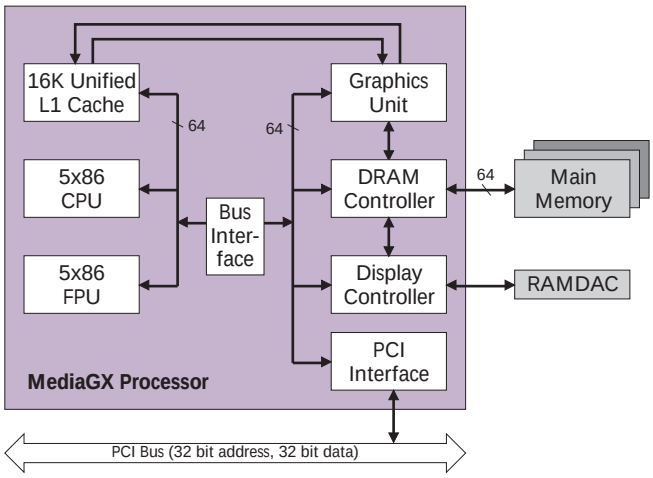

Figure 1. The MediaGX combines a scalar x86 CPU core with 16K of on-chip cache and a variety of system logic.

on a page miss, just as Pentium takes longer on a cache miss. The hit rate of Pentium's L2 cache is likely to be somewhat better than the hit rate of the DRAM page buffers, however, reducing the performance of the MediaGX relative to a Pentium with L2 cache. If both processors are configured without L2 cache, the Cyrix chip will clearly do better. The MediaGX does not support an L2 cache, as there is no appropriate place to connect one.

Putting the graphics accelerator on the chip improves performance. As Figure 1 shows, the graphics unit has direct access to the data cache at the full clock speed of the processor, allowing fast and efficient data transfers. The graphics unit is also tied directly to the memory controller. Cyrix takes advantage of this feature to implement a unified memory architecture (UMA) in which the frame buffer exists in main memory instead of in a separate memory space.

UMA has not caught on in PC designs, although several chip sets now support it *(see* **090801.PDF***)*. In many systems, bandwidth demands overwhelm the unified memory, sapping CPU performance. Cyrix has minimized this effect using advanced compression techniques that reduce the size of the frame buffer when it is stored in memory. By reading the compressed data, this design greatly reduces the bandwidth needed compared with reading from the much larger uncompressed frame buffer. For example, in the application-based Winstone 96 test, the MediaGX achieves a 20:1 compression ratio, eliminating 95% of the frame-buffer reads from main memory.

Cyrix claims the UMA design eliminates the cost of the 2M frame buffer, but in fact, this cost is merely hidden; there is still 2M of DRAM dedicated to the frame buffer in a MediaGX system. The Compaq unit, for example, ships with 24M of DRAM, but only 22M (actually, slightly less) is available to software. Since low-end frame buffers are built from essentially the same chips as main memory, the cost savings from the UMA design are minimal.

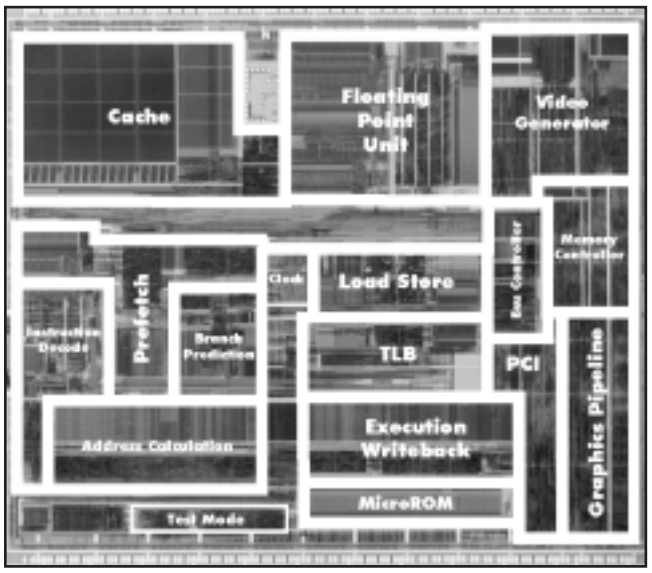

Figure 2. The Cyrix MediaGX processor contains 2.4 million transistors and measures 12 × 10 mm when built in IBM's 0.44-micron three-layer-metal CMOS-5S2 process.

Virtual System Compatibility

Cyrix needed to provide full compatibility with VGA graphics and Sound Blaster audio, legacy standards that can't be hidden behind drivers. Instead of implementing these interfaces in hardware, the MediaGX traps all attempts to access these devices and emulates their effects in software, a concept Cyrix calls virtual system architecture (VSA).

This method keeps the hardware simple while maintaining full compatibility. For example, instead of a Sound Blaster–compatible audio chip, only a simple codec is used. Performance can be as good as actual hardware; although software emulation routines can be lengthy, in some cases they execute in less time than a single access over the glacial ISA bus. Cyrix says it has tested VSA with hundreds of programs, including many DOS-based games, without finding any incompatible software.

To speed the emulation routines, VSA includes some extensions to the x86 instruction set. One key feature is cache locking. Locked sections of the cache are not loaded and stored through the normal cache-miss process; instead, VSA instructions can quickly transfer data into and out of the locked sections. These areas, which can also be accessed by the graphics unit, are typically used for critical graphics data such as BitBLT buffers.

If these buffers were loaded using standard string-move instructions, the data would go first into the unlocked portion of the cache, then into the buffers. Instead, the new MOVDB instruction transfers a block of data from memory directly to a BitBLT buffer. Similarly, the GP2MEM instruction transfers bit maps or other data directly from the graphics unit to any virtual address. Cache locking is also used to hold critical portions of the emulation routines in cache, improving performance.

The VSA extensions also include an integer multiply-accumulate instruction, useful for audio processing. Cyrix does not plan to publish the specifications for the new VSA instructions, as they are used only in the Cyrix-provided MediaGX drivers and are not intended for use in general-purpose software.

Small Design Is Easy to Build

The initial MediaGX parts are built in a 0.44-micron (drawn) three-layer-metal process that IBM calls CMOS-5S2. This is the same process used for the 6x86 at speeds up to 150 MHz. Cyrix initially announced the MediaGX at 120 and 133 MHz but, given the similarities between the pipelines of the two chips, expects the new chip to yield at 150 MHz in the current process. The chip uses a 352-lead plastic BGA package.

The MediaGX die, shown in Figure 2, is 120 mm^2, about 14% larger than a 5x86 in the same process. The on-chip system logic adds only a few dollars to the cost of the chip according to our estimates, which put the MediaGX manufac-

turing cost at about $35. A 10% shrink to 0.40-micron CMOS should reduce the die size to about 100 mm^2 and push clock speeds up to 180 MHz. These parts will use a 2.5-V core rather than the 3.3-V supply of the initial parts.

The manufacturing arrangements for the MediaGX are different than for Cyrix's other chips. While IBM continues to build chips for Cyrix, it has no rights to market the MediaGX, unlike the 6x86. SGS-Thomson, which has built and sold the 5x86, is not involved with the MediaGX at this time.

Cyrix notes the small die size, three-metal design, and relatively coarse transistors of the MediaGX would make it compatible with a variety of commercially available processes. The company would not comment further on its manufacturing plans but is rumored to be negotiating with a major Asian foundry to build MediaGX chips. Such a strategy would break new legal ground, as all the company's x86 processors to date have been produced by chip makers with an Intel patent cross license; Asian foundries such as TSMC and Chartered have no such licenses.

Cyrix needs an alternative manufacturing strategy to significantly increase its output. To service demand for the 6x86 and initial MediaGX shipments, the fabless vendor is already running at the capacity limit of its initial agreement with IBM. Cyrix has not exercised its option to purchase additional wafers from IBM; we believe these extra wafers come at a significant price premium. Because a single wafer yields more MediaGX than 6x86 chips, Cyrix can increase its unit shipments by converting to the smaller chip, but the MediaGX also carries a lower selling price, so the revenue impact of this change may not be positive.

SGS-Thomson could help ease this capacity crunch by building 6x86 chips, but despite months of trying, the company can't seem to do it. The smaller, simpler MediaGX, on the other hand, seems better suited to that vendor's abilities. As MediaGX volumes increase, Cyrix will probably turn to SGS-Thomson as a second source, but if the Europeans can't come through, an Asian fab may be the next stop.

Extensive Roadmap for Future Improvements

Now that Cyrix has established a customer base for the new pinout, it plans to stick with that pinout for quite some time. As Figure 3 shows, a 150-MHz part, which is already sampling, is due to ship next quarter, with the 10% shrink providing 166- and 180-MHz parts by the end of the year. Pentium skipped the 180-MHz mark because the external 60-MHz bus slowed accesses to L2 cache and DRAM; a 180-MHz MediaGX makes more sense because, with no external 60-MHz bus, it continues to access memory as quickly as possible. Although the 180-MHz CPU can reduce the PCI speed to 30 MHz instead of 33, in a closed system, the PCI bus can actually run at 36 MHz, improving performance.

To distinguish the faster parts from the initial 3.3-V parts, Cyrix uses the code-name GXi, indicating the 2.5-V core. A third-generation part, known as the GXm, is slated to sample late this year and begin shipping in 1Q98. The GXm

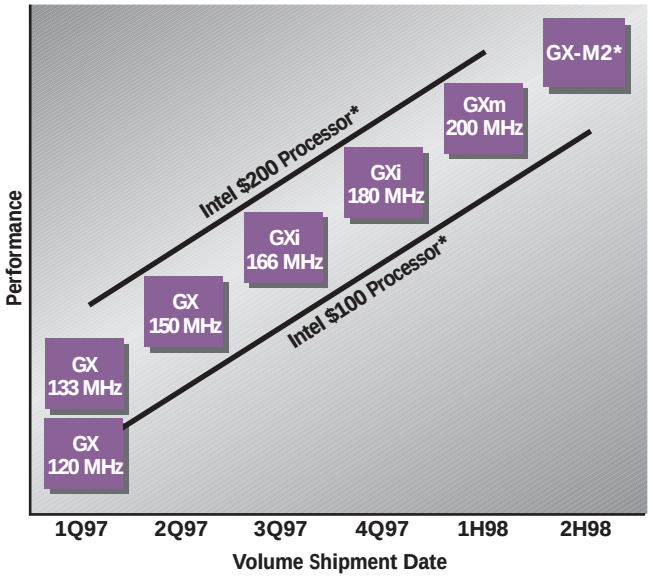

Figure 3. Cyrix's MediaGX roadmap shows clock speeds increasing to 200 MHz by 1Q98, followed by a new core for additional performance. (Source: Cyrix except *MDR projections)

will include support for Intel's MMX instructions and contains circuit enhancements aimed at a 200-MHz clock speed.

After that, Cyrix plans to improve performance by changing the core CPU while retaining the same pinout. The company did not offer specifics, but we expect the M2 core to appear in the MediaGX line in 2H98. By this time, the M2 should be in IBM's 0.27-micron CMOS-6S process, bringing its die size down to about 130 mm^2. Adding the integrated system logic might push this up to 145 mm^2, but the cost of such a die would still be low enough for the MediaGX line.

Ultimately, a move to a true 0.25-micron process such as IBM's CMOS-6X *(see* **101203.PDF***)* would bring the die size below 100 mm^2 and greatly reduce the cost of an M2-based MediaGX chip. These changes will be necessary to keep pace with Intel, which plans to move almost entirely to the P6 family by the end of 1998.

Feature Set Must Also Improve

A downside of integrating system logic is that Cyrix must also continue to add features to its design, tracking improvements developed by chip-set vendors. For example, the GXm's on-chip memory controller will add SDRAM support, a feature that is widely available in today's system-logic chip sets. Cyrix's roadmap currently shows no plans to add 3D graphics acceleration to the MediaGX processor. We expect 3D acceleration to be a standard feature in low-end PCs by the end of this year.

Other system features are handled by the so-called south bridge chip. The initial version, called the Cx5510, provides a basic ISA interface and connects to the audio codec. Cyrix expects to deliver in 3Q97 a new version, the 5520, that adds emerging features such as AC97 audio and USB support. The new part also integrates a RAMDAC and

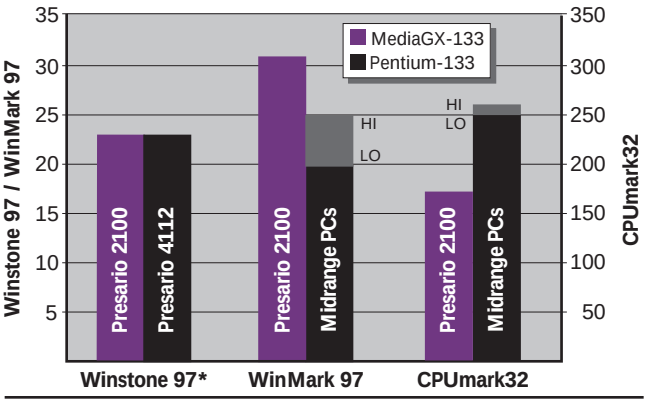

Figure 4. Compaq tested its MediaGX-based Presario 2100 with 24M of EDO DRAM, a 2.0G Quantum hard drive, an 8× CD-ROM, and the on-chip graphics unit against a Presario 4112 with similar DRAM, hard drive, and CD-ROM, a Pentium-133 CPU, 256K L2 cache, and a S3 Trio64V+ graphics chip. Both systems performed similarly on the application-based Winstone 97 benchmark. Compared with a representative sample of midrange Pentium PCs, the MediaGX system fared much better on WinMark 97 but much worse on CPUmark32. (Source: ZD Labs except *Compaq)

nonvolatile storage, eliminating these two external components from the system. The 5520 includes acceleration features for MPEG-1 video, specifically pixel scaling and YUV conversion; these features, found in most current graphics chips, are not supported in the initial 5510.

The MediaGX is also suited for notebook designs, and Cyrix is making improvements in this area as well. The 5510 will drive a TFT panel but not a DSTN display; an additional small chip, scheduled for 4Q97 availability, will add DSTN support. The integration of the MediaGX helps reduce physical size and power dissipation, and the processor itself dissipates only 5 W (maximum) at 133 MHz. Because notebook performance lags that of desktop systems, the MediaGX-133 can serve in midrange notebooks even though it fits only into the low end for desktops. Cyrix expects the first MediaGX notebooks to appear by midyear.

Application Performance Matches P54C's

On typical PC applications, the MediaGX delivers performance similar to that of a Pentium on a clock-for-clock basis, as Figure 4 shows. The Compaq Presario 2100 delivers a ZD Business Winstone 97 score of 23.3, comparable to that of a similarly configured Pentium-133 system from Compaq. This score also matches well against Winstone 97 scores on low-cost Pentium-133 systems from other vendors.

Because of the MediaGX chip's integrated graphics unit, an apples-to-apples comparison is more difficult than it seems. The Compaq Pentium system in Figure 4, for example, uses an S3 Trio64V+ graphics accelerator, a fairly pedestrian device that the MediaGX beats hands-down on performance. Conversely, as the CPUmark numbers in the figure show, the MediaGX scores significantly lower than a Pentium-133 on CPU-intensive tasks, due mainly to its scalar CPU core and lack of an L2 cache.

Price & Availability

In a 352-pin BGA, the Cyrix MediaGX lists for $79 at 120 MHz and $99 at 133 MHz; both prices are in quantities of 1,000 and include the processor, the Cx5510 PCI-to-ISA bridge, and software drivers. Both parts are available immediately. Contact Cyrix at 972.968.8388 or access the Web at *www.cyrix.com/process/prodinfo/mediagx/mediagx.htm.*

On tasks that stress only the CPU, such as spreadsheet recalculation or database lookup, the 133-MHz MediaGX will fare much worse than a 133-MHz Pentium. Most PC applications, however, mix CPU and graphics tasks; Winstone 97 is based on eight of the most popular PC programs and presumably shows a representative mix. For these applications, a MediaGX system will deliver performance comparable to that of an entry-level Pentium system of the same clock speed.

If the Pentium system has a more expensive graphics card, however, its performance is likely to exceed that of a MediaGX system on both application and CPU-intensive benchmarks. In addition, the MediaGX, like other Cyrix chips, will come up short on programs that emphasize floating-point arithmetic, a feature not measured by Winstone but used in some PC games.

Finally, the MediaGX will not match up as well against a P55C Pentium because the latter chip boosts application performance by about 10% *(see* **101404.PDF***)*. Until the MMX-enabled MediaGX appears, the P55C will also have a large advantage on multimedia applications that take advantage of the new instruction-set extensions.

Despite these concerns, the MediaGX should remain ahead of Intel's low-end processors on typical PC applications throughout this year, particularly when entry-level system configurations are compared. Intel plans to move its low-end processor from 120 MHz to 150 or 166 MHz by the end of this year, but the P55C won't reach the lowest price points until 1H98. Cyrix's 180-MHz parts should be competitive at year-end, but MMX will be required in 1998.

Cost Savings Are Impressive

Cyrix's pricing is very competitive: $79 for a 120-MHz MediaGX processor or $99 for a 133-MHz version, both in 1,000-unit quantities. These prices include the processor, the 5510 south-bridge chip, and the audio and graphics software drivers required for the new design. By comparison, Intel's 1,000-piece list price for a Pentium-133 is $134. To reach a similar feature set, one must add a low-end chip set, pushing the total Intel cost to about $154.

The system-level cost savings continue to mount if one considers the graphics accelerator and L2 cache SRAMs that are needed in a Pentium PC but not in a MediaGX sys-

tem. The integration level of the MediaGX can also reduce costs for the motherboard (PCB) and power supply. Taking all these costs into account, the MediaGX could save PC makers about $100 per system compared with a Pentium PC. Roughly half of these savings are due to the integration of the MediaGX, while the other half are simply from Cyrix's aggressive pricing.

While these total cost savings are impressive, given the low margins of the PC business, they represent a potential savings of perhaps $150 off the retail price of a system. Cyrix claims the MediaGX will open new markets by enabling full-featured PCs to sell for less than $1,000, but the Presario 2100 isn't even a sub-$1,000 PC: it costs $1,245 with a monitor. For most applications, the Presario will clearly outperform true $1,000 PCs from Packard Bell and Monorail, but there is nothing new about its price point.

Future MediaGX systems may breach the $1,000 price point with a monitor by offering less generous amounts of DRAM and disk space. These systems, however, are likely to have a smaller edge over Intel-based competitors. In short, the MediaGX offers tangible benefits to PC makers but is unlikely to change the overall PC market or the products in which x86 processors are used.

Cyrix Finds a Niche

When Cyrix brought out its 6x86, rivaling Intel's fastest chips, the smaller vendor found out how difficult it is to compete head to head with Intel, and the company is still bruised from this encounter. Although it took time and hard work to establish, the MediaGX now appears to have found a niche where Intel has no competitive product, either in terms of price or feature set.

The new processor appears well on its way to being a success in the marketplace. In addition to Compaq, several second- and third-tier players will soon deploy MediaGX systems, according to Cyrix. Infrastructure support for the MediaGX will come from eight motherboard vendors and two BIOS vendors.

Cyrix expects the MediaGX to quickly match its 6x86 unit shipments, with more than half of these chips going to vendors other than Compaq. Unfortunately, this demand will exacerbate the fabless vendor's capacity crunch. There are worse things than having more demand than supply for a product, and Cyrix hopes to increase its capacity soon. If the vendor can solve this problem and execute according to its roadmap, the MediaGX should make a major contribution to Cyrix's recovery. M