Digital Plans Broad Alpha Processor Family

New High-End, Low-End Chips in the Works; 200-MHz Availability Delayed

By Linley Gwennap

At the Microprocessor Forum, Digital Equipment Corporation (DEC) spokesman Mike Uhler laid out a five-year plan for a complete family of microprocessors based on Alpha, which is now officially dubbed the Alpha AXP architecture. On the high end, DEC plans to offer higher-frequency versions of the EV-4 (formally known as the 21064), followed eventually by completely new chip designs with more parallel issue and larger caches. The company will also aggressively pursue the low-cost market with a family of Alpha chips specifically aimed to cut cost and power.

High-End Plans

Digital has established two processor design teams to push the frontiers of Alpha performance. One team is currently finishing the EV-4 chip *(see **060301.PDF**)*, which uses DEC's CMOS-4 process. Although DEC considers this a 0.75-micron (drawn) process, its small effective gate length and very thin gate oxide are comparable to a half-micron process. EV-4 is currently in production at 150 MHz, with usable yields at up to 182 MHz. The new Alpha servers use the faster chips, while higher-volume workstations use chips at 150 MHz and below (see sidebar). Digital is refining CMOS-4 to improve yields at the higher frequencies; it expects EV-4 to be yielding in volume at 200 MHz by 3Q93. At that time, the company will make these higher-frequency chips openly available.

The EV-4 team is porting that design to the planned CMOS-5 process, which reduces the feature size by 33% and adds a fourth metal layer. DEC expects the new design, called EV-45, to increase the clock speed to 300 MHz. In addition, the smaller gates will allow the on-chip caches to be doubled, to 16K of instructions and 16K of data. It will still be pin-compatible with EV-4. Although Uhler did not give a specific date for this chip, it could begin shipping around early 1994. With the clock and cache improvements, performance could be around 140 SPECint92 and 240 SPECfp92.

In the meantime, the other design team has been working on a new design called EV-5. Although Uhler gave few details about this design, it will be four-way superscalar (twice the issue rate of EV-4), probably with dual integer units, a branch unit, and one or two memory units. The floating-point unit may be split into separate add and multiply units to make up for Alpha's lack of an add-and-multiply instruction. The on-chip caches will be at least 32K each, possibly larger. The clock frequency will be at least 300 MHz. A design of this type could exceed 200 SPECint92 and 350 SPECfp92.

Given the current state of the design, EV-5 chips could go into production in late 1994. The first chips are planned to be built in CMOS-5. The company recently broke ground for a new IC fabrication facility in Hudson (Massachusetts) that it expects to be producing CMOS-6 chips with 0.35-micron (drawn) features by 1996. As soon

Alpha Systems Announced

Digital has announced the long-awaited first Alpha-based workstations, the DEC 3000 Models 400 and 500. Both systems use a 21064 CPU with a 512K external cache. The Model 400 clocks the CPU at 133 MHz and the Model 500 at 150 MHz. DEC also announced a family of servers based on the 21064; the fastest of these, the DEC 10000 Model 610, uses a 200-MHz CPU with a 4M external cache. With the announcement came the first official performance numbers for the 21064: the 150-MHz Model 500 achieves 74.3 SPECint92 and 126.0 SPECfp92, while the 200-MHz DEC 10000 reaches 106.5 SPECint92 and 200.4 SPECfp92.

The Model 400, a desktop system, is priced at $15,000 with 32M of memory, a 426M disk, and a 17" grayscale monitor. The deskside Model 500, with twice the expandability, costs $39,000 with 32M of memory, a 1G disk, a 19" color monitor, and a CD-ROM drive. The Model 400 has three Turbochannel expansion slots, while the Model 500 has six. The high-end DEC 10000 uses a data-center package and has an entry price of over $300,000. It uses both Futurebus+ and XMI for I/O, and will be expandable to six processors in the future.

All of the new systems are available immediately with the VMS operating system, except for the DEC 10000, which will not ship until 1Q93. OSF/1 will be available on the Alpha systems in 1Q93, with Windows NT to follow as soon as it is available from Microsoft.

These announcements prove that the 21064 is the fastest microprocessor available, but because DEC is unable to manufacture chips faster than 150 MHz in high volume, HP has the fastest available workstations, based on the 99-MHz PA7100 (80.0 SPECint92, 150.6 SPECfp92). Even at 150 MHz, the 21064 is significantly faster than current R4000 or SuperSPARC chips, particularly in floating-point performance.

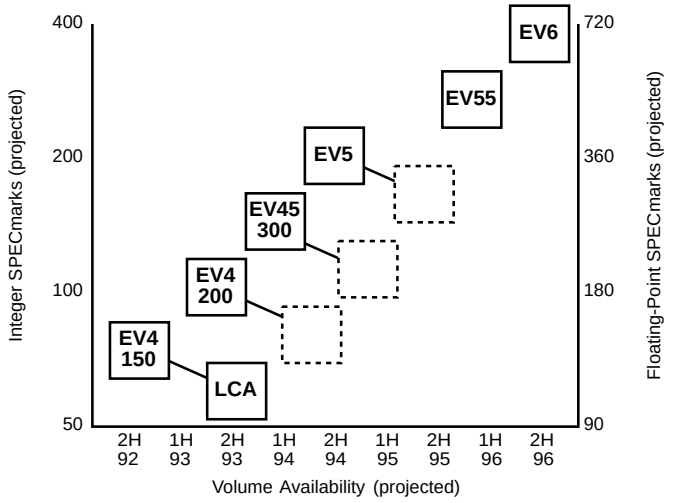

Figure 1. Future Alpha microprocessors. Projections by µPR based on statements by Digital and other industry sources.

as the Hudson facility is ready, the EV-5 design will be shrunk to CMOS-6 to increase the clock rate and cache sizes. Of course, there are many opportunities for delays in a program of this duration and magnitude, but these appear to be reasonable estimates.

As the EV-4 design team completes the current chip, the team is beginning to look at a future chip called (you guessed it) EV-6. This design will be the first to take advantage of the knowledge gained from users of the first Alpha systems. No details are available, since the design effort is just starting, but EV-6 will use the CMOS-6 fab and thus is not expected until 1996 or later.

Low-Cost Alpha (LCA)

A third Alpha design team is developing a chip called LCA aimed at low-cost systems. Digital is aggressively promoting Alpha for use in Windows NT systems, and LCA is a key to this strategy. Although DEC plans to sell high-end NT systems using EV-4, that chip is too hot (23 Watts at 150 MHz) and too expensive ($800) for mainstream PC-class products.

LCA, to be marketed as the 21066, is similar to TI's microSPARC *(see **061402.PDF**)* in that it combines the CPU, floating-point unit, instruction and data caches, memory controller, and I/O interface onto a single chip. This high degree of integration reduces overall system cost by eliminating external system logic, even if the microprocessor itself is relatively expensive. LCA will have the same 8K/8K caches as EV-4, which are much larger than the 4K/2K caches on microSPARC. Instead of microSPARC's SBus interface, LCA will interface to PCI, a next-generation PC bus developed by Intel. This allows LCA systems to take advantage of the same PCI graphics and I/O chips that x86 PCs will use.

DEC's goal is for LCA to enable low-cost systems with the same performance as more expensive Alpha systems. This outcome is not only unlikely but would cause serious pricing problems if it came true. Even if LCA uses the same integer and floating-point core from EV-4, performance will be lower due to the PCI interface. The external cache, if supported at all, will probably be smaller and slower, to reduce cost. The clock rate of LCA systems will probably be around 100–150 MHz; even at the top of that range, LCA is unlikely to significantly exceed the integer performance of Intel's Pentium, so DEC will have to compete on the basis of system cost and floating-point performance.

LCA systems should ship around 4Q93. Many other RISC vendors are developing similar low-cost processors for that time period, including IBM's PowerPC 601 *(see **061401.PDF**)* and HP's PA7100LC *(see **061503.PDF**)*. These three chips should have similar performance, although neither the IBM nor the HP chip includes as many functions on the processor as LCA.

In the Windows NT world, another competitor will be QED's low-cost MIPS chip called Orion *(see **061507.PDF**)*. LCA will probably have better performance than Orion, particularly on floating-point code, but most PC users don't use floating-point math very often. QED is targeting a very small die size for Orion; it is likely that this chip will be much less expensive than LCA, although it will not include a full set of system functions. Orion, like other MIPS chips, will be sold by several vendors; this competition is likely to keep prices low. DEC has the advantage of making its own chips, but other Alpha system vendors must pay whatever DEC wants to charge.

Enabling Chip Sales

Digital is committed to establishing Alpha as the 64-bit architecture of choice. To accomplish this lofty goal, the company is selling the EV-4 on the open market under the name DECchip 21064, and promises to make future Alpha chips available as well. DEC's Semiconductor Operation has a large sales support staff just for Alpha microprocessors.

DEC is offering a range of design support services, including chip logic models and sample system designs to help its partners cope with the challenges of a 150-MHz design. Digital also committed to making available the

Price and Availability

The DECchip 21064 is currently in production at 150 MHz. The "1993 volume pricing" is $1096 in quantities of 1,000 or $800 in quantities of 50,000. The chip uses a 431-pin ceramic PGA package. Contact Digital Equipment Corporation at 800/DEC-2717 or 508/568-6868, or contact your local DEC sales office.

memory, graphics, and I/O interface chips that it is developing for its own products, although no details have been released on these potential new chip products. Since the company is new to the merchant microprocessor business, initial customers may have a rough road until these tools and services reach the quality level of other vendors'.

The most intriguing tools are binary translators from VAX or MIPS to Alpha. These tools basically recompile a program without needing the source code, to which some customers may not have access. Unfortunately, the translated binaries do not run as fast as programs compiled from source code for Alpha; DEC claims a degradation of about 50%. Even with lower performance, binary translation can save a customer from rewriting old applications. The current translators are of most interest to Digital's installed base, but the same technology could be applied to translate x86 code, for example. With Windows NT ported to Alpha, an x86 translator would be a useful tool.

Alpha Report Card

The early results for Alpha are mixed. Digital gets kudos for designing a world-class microprocessor from scratch and getting it to market in a timely manner. The 21064 uses a more advanced CMOS process than any other microprocessor currently in production. The company's willingness to make all of its processors and related technology available on the open market differentiates it from IBM and HP, the other performance leaders. Alpha systems should provide attractive upgrades to DEC's installed base, allowing DEC to unify its workstation and server product lines around a single in-house architecture.

Even with these advantages, the program has been hyped beyond what the company can deliver. The first setback is the company's inability to produce 200-MHz chips in volume, despite its boastful claims six months ago that the yield curve was centered above 170 MHz. The plan to build a broad family of Alpha processors, as outlined by Uhler, would strain the resources of any large computer company. Digital, in the throes of major staff reductions caused by billion-dollar losses, will be hard-pressed to keep up with the plan.

DEC, like the other major players, has realized that an architecture must be supported by multiple companies to succeed. After the initial flurry of deals died down, the Alpha partner list consisted of Digital, Cray, Kubota, and Olivetti; niche players Raytheon and Encore are the only recent additions, although DEC believes that other deals are "in the works." Other than Digital itself, only PC-maker Olivetti is likely to sell large volumes of Alpha systems, although Cray is certainly an influential player at the high end. DEC continues to search for a second IC source after being turned down by practically every major semiconductor vendor in the world. Since Digital is unwilling to idle its own fabs to buy parts from outside, the chip companies are presumably waiting to see if Olivetti (or potential new partners) succeeds in establishing a broad Alpha market.

The lack of progress in signing up partners shows that, despite its technical strengths, Alpha may be too little, too late. Since their introduction, HP's PA-RISC and IBM's POWER have taken market share from SPARC and MIPS by offering products with up to twice the performance of their competitors. Now that the hype has cleared, Alpha appears to be a good product but not the breakthrough that Digital had hoped for.

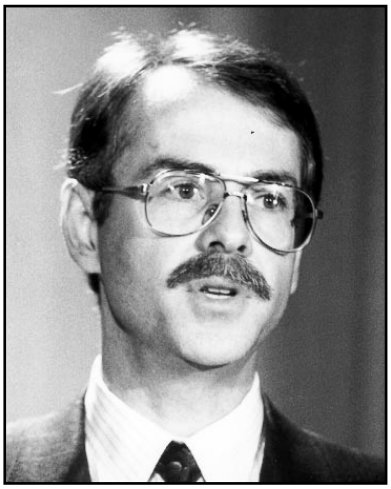

PHOTO BY ANNE HAMERSKY

"The Alpha AXP program pulls together Digital's core competencies in the areas of CMOS technology, compilers, and microprocessor design and builds on years of experience in systems integration. The result is a family of microprocessors delivering industry-leading performance today and into the 21st century."

Mike Uhler, DEC

DEC's successful courtship of Microsoft may hold the key to Alpha's future in the merchant market. As Windows NT levels the software playing field, Digital may be able to establish a price/performance advantage over x86 and MIPS systems. Even a small portion of this market would boost the volume of Alpha systems, attracting new system and semiconductor partners. If NT does as well as the original Windows, potent microprocessors from IBM, HP, and Sun could be stuck with the less popular UNIX and Macintosh O/S for these PC-class products. An important issue for DEC is whether applications developers will support binaries for all three Windows NT architectures; if not, even a well-designed LCA system could be rendered worthless by a lack of application software.

So far, Alpha has made a good effort and gets a "B" for the first quarter. No matter what happens in the merchant market, Alpha gives Digital customers a solid upgrade path from their current systems and makes DEC competitive in the workstation market. It does not leapfrog the competition, as the company had hoped, but by supporting Windows NT and PCI, it is well-positioned for the high-volume market. Alpha's success in the merchant market will require the timely delivery of powerful, low-cost microprocessors, aggressive marketing, and support from lots of software vendors. ♦

