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RISC Ambushed by Pentium Pro

PowerPC Stumbles, RISC Vendors Lose Momentum in 1995

A LOOK BACK 95 96 A LOOK AHEAD

by Linley Gwennap

Last issue, we reviewed the x86 and embedded markets. This article covers the RISC processor market of 1995 and offers a preview of the coming year. Our new Chart Watch feature (see **1001CW.PDF***) provides additional information on these RISC processors.*

The past year was supposed to be an opportunity for the RISC processor vendors, in particular the PowerPC vendors, to build a credible threat to Intel upon the foundation of 1994's initial successes. Instead, an embarrassing sequence of mishaps left the PowerPC triumvirate with the wind whistling through an empty frame, as IBM and Motorola couldn't deliver enough chips, Apple couldn't enough deliver systems, and no other vendors were ready to fill the gaps. Despite these problems, PowerPC outsold all other desktop RISC processors combined.

In contrast, Intel executed its product plans extremely well *(see* **091701.PDF***)*. The x86 leader slashed its Pentium prices repeatedly, leaving RISC vendors unable to keep up. A quick move to 0.35-micron technology improved Intel's clock speeds while reducing its manufacturing cost. Finally, at year end Intel rolled out its new Pentium Pro as the fastest microprocessor on the planet, leaving the RISC vendors behind in performance as well as sales.

RISC chip makers made several positive accomplishments. Perhaps the biggest was Sun's shipment of UltraSparc, revitalizing SPARC performance for the first time in years. Digital continued to lead the RISC performance race by shipping its 21164 processor.

To commemorate both the best and the worst RISC events of 1995, we offer our traditional RISCie awards. Note that these awards include neither x86 processors nor RISC processors primarily serving the embedded market.

Alpha Performance Edged by Pentium Pro

After holding the integer performance lead for an unprecedented three years, Digital's Alpha family was surpassed by Pentium Pro at the end of 1995, as Figure 1 shows. At this time, we can still offer Digital the award for **World's Fastest RISC Microprocessor (shipping)**, on both integer and floating-point code, for its 300-MHz 21164. As the figure shows, Alpha may lose even this position when HP's PA-8000 debuts in a few months. Digital's 417-MHz 21164 (née 21164A) should regain the lead in 2Q96, but it is clear that Alpha's position as the unchallenged leader of the pack is a thing of the past.

EDITOR'S CHOICE UltraSparc BEST RISC PROCESSOR SEE PAGE 7

The company earns the **Needs an Energizer** award, as this loss is due to a slowdown in Digital's pace: the 417-MHz part represents a performance increase of 42% over the past year. Other vendors are improving at 60% per year or more, closing the gap with Alpha. Although Digital denies that the

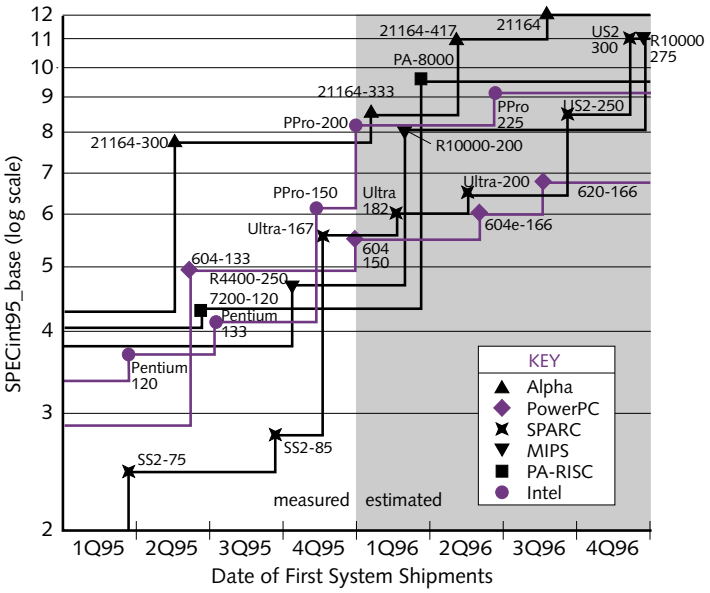

Figure 1. Pentium Pro has seized the integer performance lead but will battle with a series of RISC processors in 1996. (Source: SPEC for 1995; vendor, MPR estimates for 1996)

recent cost cutting needed to eliminate its corporate losses has affected its Alpha investment, something has adversely impacted the end product.

In a clear cost-cutting move, the **Grim Reaper** visited Alpha's low-end line, removing the 21066 from Digital's product plans. Instead, the company is using older 21064 and 21064A processors in its low-end boxes, eliminating the expense of developing integrated low-end processors.

This strategic change forced Mitsubishi to **Man the Lifeboats.** That vendor had planned to ship the 21066 as its first Alpha product, but there are now no customers for the chip. In fact, outside of Digital, Cray, and a few tiny PC makers, there remains very little market for any Alpha processors; we expect Mitsubishi to abandon the Alpha ship in 1996.

Thus, Alpha remains essentially an in-house architecture for Digital. The company's attempts to commoditize its processors have met with indifference from the start. Perhaps the final error was keeping the prices of its high-end processors—the only ones offering a performance advantage over the competition—at stratospheric heights: the 21164 remained the **Most Expensive Microprocessor**, at $2,937, throughout 1995. The company recently reduced this part to $1,375 as the new 333-MHz part adopted the higher price.

As a system vendor, Digital is doing better. The company has nearly completed moving its customers to Alpha from MIPS and VAX. Its workstations, with leading performance at a variety of price points, are gaining attention. The company has moved faster than any other to integrate its PC and workstation lines, positioning Alpha well for combat with Pentium Pro. Digital even posted four consecutive profitable quarters. Yet buyers remain skeptical of Digital's financial position and its ability to sustain Alpha's high performance without significant support from other system vendors.

Digital's one hope to break out of its niche is an attack on the PC market. Alpha is currently doing better than any other RISC in the Windows NT market, and the company hopes to parlay this success into bigger volumes as NT becomes a more mainstream OS. Alpha's success, however, has been aided by PowerPC's late start and MIPS's near abandonment of the field; Intel continues to dominate the NT market. Digital's FX!32 emulation technology could give it an edge, but to make any headway in this market, the company must cut its chip prices, putting its fastest processors into inexpensive PCs.

PowerPC Grows Despite Mistakes

In 1995, the PowerPC 601 retained its title of **Best-Selling Desktop RISC Processor**, but this was not good news for the triumvirate of IBM, Motorola, and Apple. The PowerPC 603 and 604 were expected to make more headway but didn't get on track until late in the year. The 603 ran into trouble when tests revealed that its small, split caches (16K total, half the size of the 601's unified cache) significantly reduced performance on Apple's 68K emulator. This problem was eased with the 603e, which increased the total cache size to 32K. Apple is now shipping both 603- and 603e-based systems.

Using the same marketing plan that last year earned the 603 a **Phantom Product** citation, Motorola and IBM announced "volume" shipments of the PowerPC 604 in December 1994, but the processor didn't surface in systems until six months later. In this case, the chip suffered from a variety of functional and production problems that took months to resolve. When it finally appeared, its clock-for-clock performance edge over Pentium had shrunk from 60% to 25% on SPECint95, and with Intel's 166-MHz Pentium now shipping *(see* **1001MSB.PDF***)*, the 604 is lagging in clock speed.

At least the 604 fared better than the 620, which gains the **Mark Twain** ("The reports of my death are greatly exaggerated.") award. Various PowerPC watchers took turns dancing on the 620's grave as the chip slipped well beyond its 3Q95 due date with no shipments in sight. Our sources, however, indicate that the 620 has not been terminated and is most likely to appear around 2Q96, using a 0.35-micron gate shrink to boost its anemic performance. Both IBM and Groupe Bull remain interested in the 64-bit device for high-end servers, and Motorola says it is also committed.

At least the 620 is in better shape than the PowerPC 615. Sources indicate IBM has finally **Pulled the Plug** on this device, which combined a PowerPC core with an x86 decoder but never shipped. Other experiments combining x86 and PowerPC continue at IBM and Motorola, but these involve a combination of hardware and software emulation, and none is likely to appear in systems during the next year.

The tribulations of the 603, 604, and 620 convinced IBM and Motorola to reorganize the Somerset Design Center and seek a new leader to replace the previous two-headed system. After a six-month search, Mark McDermott, late of Cyrix, has agreed to take what we think is the **Industry's Toughest Job.** Good luck, Mark!

The third PowerPC partner, Apple, made its share of gaffes during 1995, the most publicized being shortages of many Power Macintosh systems, grabbing the **Jeane Dixon Forecasting** award. Although Apple's misforecasting affected several key components, microprocessors were a part of the problem. Once Apple realized its mistakes, neither IBM nor Motorola could ramp production of advanced PowerPC chips quickly enough to prevent Apple's shortages.

Potential Macintosh buyers had nowhere to turn but x86-based PCs. Earning the **Too Little, Too Late** award, Apple's momentous decision to license the Macintosh OS left five small companies holding the only Mac licenses, and none could even attempt to fill the shortfall left by Apple's mistake. Apple had reportedly turned down major PC makers, including Acer and Gateway, as Mac licensees for fear of losing too much of its own hardware business. Instead, Apple's restrictive licensing strategy further lined the pockets of Intel and Microsoft.

In spite of these problems, Apple has nearly completed its transition from 680x0 to PowerPC without losing significant market share. Indeed, some studies found Apple as the

top PC vendor, but these gains came at a cost: the company expects a loss of more than $60 million for the past quarter. Overall PowerPC system sales grew from about 800,000 in 1994 to nearly 2.5 million last year, earning PowerPC the **Fastest Growth** award.

Almost all these sales were due to Apple's efforts; IBM's much anticipated RISC-based PCs finally appeared in June with little software, high prices, and not enough performance to garner significant sales, making the announcement the **Biggest Nonevent** of 1995. As OS/2 for PowerPC twists in the wind, IBM appears to be finally backing away from OS/2, which could open the door for a Mac OS push.

In the **Better Late Than Never** category, Apple, IBM, and Motorola agreed on a common hardware reference platform. CHRP machines will run any PowerPC operating system, including Mac OS. Several system vendors plan to build CHRP systems, which give them needed flexibility as the tangled PowerPC software story continues to unfold, but first shipments won't occur until late this year.

In the coming year, the semiconductor partners will continue to deploy faster versions of the 603 and 604 utilizing 0.35-micron and 0.28-micron shrinks. With no new cores on tap until 1997, however, PowerPC's relative performance position is unlikely to improve from its current state: the 604 outperforms Pentium while trailing other high-end RISCs as well as Pentium Pro. The 620, should it appear, is also likely to fall behind other high-end processors, as Figure 1 shows. The PowerPC chips have a big advantage over Intel's processors for floating-point applications, but the system vendors haven't been able to turn this into a compelling advantage for most users.

On the system side, Apple will complete its PowerPC transition (mainly because its customers are refusing to buy 68K systems) while slowly building a small group of Mac clone vendors. The latter effort could accelerate if Apple management changes or if the company is sold, as has been frequently speculated. IBM appears uninterested in an aggressive PC push for its RISC architecture, instead focusing on converting its server business while offering low-priced workstations. PowerPC sales will continue to rise in 1996 but offer little threat to x86 dominance.

UltraSparc Revitalizes Sun Performance

Sun's solid execution of its UltraSparc program stands in stark contrast to the problems of its RISC competitors (and to its own past experience with SuperSparc). The complex processor exceeded its clock-speed and performance goals while appearing within a couple of months of its original schedule. For a variety of reasons, we selected UltraSparc as our **Editor's Choice** among RISC processors.

Although UltraSparc can't match the performance of Digital's 21164, its integer performance exceeds that of all other RISC processors shipping today, as Figure 1 shows. The SPARC chip has several advantages over the 21164. For example, UltraSparc has the **Best Memory Bandwidth**

Major RISC Events of 1995

Digital deployed its first 21164 servers (0905MSB.PDF), then added workstations using the 21164 (0911MSB.PDF). The company announced a 333-MHz version (0913MSB.PDF), followed by the 417-MHz 21164 (0914MSB.PDF).

Digital reported its first annual profit, but the growth in Alpha sales slowed in fiscal 1995 (0912MSB.PDF). The company revealed plans for its FX!32 x86 emulator (0916MSB.PDF).

Apple announced the first Macintosh licensees (0901MSB.PDF) and revamped its Power Mac line (0911MSB.PDF). IBM plans to ship Mac OS in 1996 (0910MSB.PDF). Jean-Louis Gassée's new firm, Be, debuted the PowerPC-based BeBox (0914MSB.PDF).

The PowerPC 603e was announced at 100 MHz (0902MSB.PDF), then jumped to 166 MHz (0911MSB.PDF) as Motorola planned to match IBM's 0.35-micron CMOS process (0912MSB.PDF).

The PowerPC 604 emerged in PCs and workstations from Apple, IBM, and others (090803.PDF); IBM pushed the 604 to 150 MHz (0916MSB.PDF); the 604e is due to boost speed further in 1H96 (0914MSB.PDF).

IBM created PowerPC processors specifically for its AS/400 line (091004.PDF). IBM and Motorola began a search for a new head of their Somerset design center (0908MSB.PDF); newcomer Exponential confirmed its plans to build a PowerPC processor (0917MSB.PDF).

Sun's UltraSparc rolled out at its target clock speed of 167 MHz (090703.PDF), then hopped to 182 MHz (0913MSB.PDF); Sun's roadmap includes a 300-MHz UltraSparc-2 in 1996 (091505.PDF). MicroSparc-2 jumped to 110 MHz (090703.PDF).

Ross pushed its HyperSparc processor to 125 MHz (0906MSB.PDF) and then 150 MHz, with 200 MHz in the plan (091604.PDF).

Hal revealed its multichip Sparc64 processor (090301.PDF), which appeared in Hal systems (0913MSB.PDF).

MIPS extended its processor roadmap (0903MSB.PDF) and boosted the R4400 to 250 MHz (0908MSB.PDF). Galileo introduced a cache controller for Orion MIPS chips (0903MSB.PDF).

HP's PA-7200 chip shipped in systems at 100 MHz (0905MSB.PDF) and later reached 120 MHz (0908MSB.PDF). HP taped out the PA-8000 (0904MSB.PDF) and revealed the PA-7300LC design (091503.PDF). NEC signed up for PA-RISC (0903MSB.PDF).

Pentium Pro surpassed the integer performance of all RISC processors (see 091501.PDF). Data General dropped Motorola's 88000 from its future plans, moving to Pentium Pro (see 0909MSB.PDF).

among all microprocessors *(see* **1001CW.PDF***)* and Sun provides all the support logic needed for multiprocessor systems, making its chip ideal for powerful servers. At prices ranging from $995 to $1,595, UltraSparc is also less expensive than the Alpha chip.

We also find Sun's VIS instruction set to be the **Most Innovative** feature among this year's chips. While others have added multimedia-handling instructions to their processors, VIS is the most powerful and complete set to date, and Sun brought it to market ahead of competitive extensions from Intel and PowerPC, among others. VIS should help Sun in the workstation market, but the company must build a base of VIS-enabled software and rapidly move VIS into its high-volume systems. Sun has an ISV program to encourage the former, and the cost-reduced UltraSparc-2, due in 2H96, should address the latter issue.

Sun's success in other areas was more limited. Before Sun could say **Good Riddance**, SuperSparc produced one final frequency disappointment: a 90-MHz version was announced for 1Q95 shipments but never made it, although an 85-MHz version was eventually substituted. Sun boosted MicroSparc-2 to 110 MHz in 2Q95, replacing a 100-MHz version that was expected in 3Q94 but never shipped. The 110-MHz processor must hold the low-end fort until MicroSparc-3's debut, which is expected in 1H97 *(see* **1001MSB.PDF***)*. Since the current 110-MHz device offers no better performance than a 100-MHz Pentium, even on floating-point code, this could leave Sun's low end vulnerable in the interim.

Ross Technology continues to perk along, pushing its HyperSparc line to 150 MHz, with a 200-MHz version due around mid-1996. The latter should drive performance into the low end of the UltraSparc range, but with UltraSparc-2 on deck, this is unlikely to gain Sun's attention. Thus, Ross will most likely focus on the end-user upgrade market, where its MBus-compatible devices have been successful.

Last fall, Hal Computer finally shipped its first products, which use the company's in-house Sparc64 processor. Although the multichip processor was announced at 154 MHz, speed problems forced the first systems to debut at 118 MHz, a SuperSparc-like disappointment. Despite this drop, Hal's workstations were briefly the fastest SPARC systems available, but they soon were passed by UltraSparc boxes. Given the high cost structure of the Sparc64 and Hal's reluctance to sell the processor on the merchant market, the Fujitsu-backed device is likely to end up as merely a **Microprocessor Footnote**.

MIPS Looks for Improvement in 1996

As evidenced by the sidebar, MIPS made little news for its desktop processors in 1995, earning the **Rip van Winkle** deep-sleep award. The only new product announced during the year was a 250-MHz grade of the R4400, but this device was hard to find in volume and, once found, expensive. The low end was covered by R4600 and R4700 products announced late in 1994, with no changes until the recent R5000 announcement *(see* **100102.PDF***)*.

MIPS has **High Hopes** for 1996, with R5000 and R10000 systems expected to debut within the next few months. While delivering an overdue upgrade to the integer performance of MIPS-based systems, the two forthcoming devices place a greater emphasis on floating-point performance than previous MIPS chips. This change indicates Silicon Graphics' dominance of the MIPS market and its graphics-intensive position in the workstation and supercomputer markets.

The Windows NT "strategy" for MIPS chips wins the **Pushmi-Pullyu** award. At one end, SGI has displayed a total lack of interest in NT. At the same time, NEC continues to flog the NT-on-MIPS platform through an extensive and, shall we say, unusual advertising campaign. MIPS Technologies, riding the middle of this two-headed beast, offers token support for NT. Realistically, the combination of high-performance Alpha and Pentium Pro chips with inexpensive Pentium and PowerPC processors has left precious little opportunity for the MIPS/NT combination on the desktop, although server vendors like Tandem and NetPower continue to be interested.

PA-RISC Prepares for Transition

The past year was a quiet one for HP as well, as the company rolled out just one new processor, the high-end PA-7200. After a wait of more than a year, this chip offered only a small (8%) gain in integer performance over the PA-7150, earning HP the **Lack of Improvement** award. The company also failed to upgrade its low-end processor, the 7100LC, during 1995. In fairness, we must point out that the 7200 offers significantly improved floating-point performance and memory bandwidth compared with the 7150; its glueless multiprocessing capabilities make it a good product for servers and pave the way for a transition to the forthcoming PA-8000.

The PA-8000 should fix HP's performance woes; as Figure 1 shows, it could briefly take the integer performance lead when systems begin shipping later this quarter. This impressive performance requires the **Biggest Die** among RISC processors, a portly 345 mm^2. The processor's requirement for two synchronous external caches will further increase HP's cost to build PA-8000 systems. For the few buyers who need this level of performance, however, price is generally not an issue.

HP plans to address price-sensitive users with its 7300LC, due in 3Q96. This integrated processor offers strong performance *(see* **1001CW.PDF***)*, particularly on the floating-point side, and will power HP's low-end and midrange workstations and servers for quite some time; the 7100LC has held this position for more than two years.

The company is also preparing for a manufacturing transition. Its IC process technology remains stuck at 0.5 micron even as competitors are leaping beyond the 0.35-micron level. HP, widely rumored to be negotiating with Intel and other vendors for fab capacity, is the RISC vendor

Most Likely to Go Fabless. Access to sub-half-micron technology is crucial for PA-RISC performance to remain competitive beyond 1996.

HP's partnership with Intel appears to be progressing well, although neither company will say much. We expect the first chip, Merced *(see* **1001MSB.PDF***)* to appear in 1998, combining compatibility with PA-RISC and x86 code with a new VLIW-like instruction set. Although Merced is being designed entirely by Intel, HP is apparently working on its own follow-on design. These chips should put HP (and Intel) in the performance lead, or at least among the leaders, but they will be built exclusively by Intel.

PA-RISC gained one new backer as NEC's high-end server division came on board, leaving other groups in NEC continuing with MIPS and other processors. The Japanese vendor plans to add a line of PA-RISC systems in 1996; implied in the deal is that NEC will move to the HP/Intel architecture when it becomes available.

Pentium Pro Casts Long Shadow

Unlike previous years, there has been little activity among system vendors switching to a RISC architecture. In fact, the most sought after vendor, Data General, chose Pentium Pro over all available RISC options when moving from the dead 88000 architecture. Intergraph also switched to x86 after abandoning Clipper and snubbing SPARC. The lure of Pentium Pro has kept other x86 system vendors in the fold, diminishing interest in PowerPC and other RISCs.

There has not been a headlong rush away from RISC, however. Other than DG and Intergraph, most RISC system vendors continue to ply their wares, satisfying their installed base and attacking niche markets where Intel processors cannot compete, such as those that require high bandwidth or fast floating point. Such markets include enterprise servers, supercomputers, and scientific workstations, conveniently areas where the RISC vendors have historically been strong.

Intel has convincingly countered, however, the RISC vendors' thrusts into the general-purpose desktop and server markets. In any area where cost is an issue, Intel-based systems are compelling. In addition to sealing off the PC market, Pentium Pro allows Intel to attack the low end and midrange of the workstation and server markets.

For example, a Pentium Pro system selling for less than $10,000 will provide far better integer performance than comparably priced and configured RISC workstations while offering similar or better floating-point performance. A four-processor Pentium Pro server will deliver enough performance for all but the most demanding applications but will sell for less than $50,000.

In the short term, RISC vendors will have a software advantage among technical users, but the large installed base of Pentium systems is already attracting ISVs, such as Cadence and Mentor, to port their workstation software to x86. Within a few years, we expect the NT/x86 platform will have as much technical software as any Unix/RISC system.

RISC Vendors Won't Give Up

Naturally, RISC vendors won't easily abandon the billion-dollar investments they have made in developing their own microprocessors. And the customer base each vendor has nurtured won't easily switch to x86. Thus, we do not project a major decrease (or increase) in RISC system shipments in the near future.

But the consequences of Pentium Pro will be felt. To retain their customers, RISC vendors must cut their system prices, not necessarily to PC levels, but much closer than today. IBM has led the way with its latest PowerPC systems, pricing its fastest 604-based workstations at about $8,000. This change will reduce gross margins, although a move to PCI and similar PC components could reduce margin pressure over time. IBM and Digital have already made this move; Sun and SGI are lagging in this area.

Second, Pentium Pro will slow, and most likely stall, the growth of RISC system sales outside of Macintosh. The grandiose plans of RISC vendors to increase sales via the PC or low-cost server markets will not come to pass, and many new workstation customers will turn to Intel-based systems, leaving RISC makers mainly to service their existing customers and some small high-end niches.

Finally, Pentium Pro has dampened interest among many companies in switching to RISC. The chances of any major PC or x86 system vendor adopting a new RISC architecture are dimming, and even smaller vendors are thinking twice. The sole hope for RISC appears to be Apple's licensing program, using Mac OS to lure system makers to PowerPC. With Copland, the next generation of Mac OS, rumored to have slipped into 1997, this lure may be ineffective. And as the HP/NEC deal indicates, the Intel/HP architecture could pick up momentum as its shipments approach.

Although some RISC processors will surpass Pentium Pro's performance in 1996, Intel should stay close enough to the lead to keep its system vendors from straying. Intel has turned its enormous cash flow into a manufacturing technology lead capable of overcoming the RISC efficiency advantage. Given current capital-investment profiles, Intel's manufacturing advantage is more likely to grow than disappear over the next few years.

Other than PowerPC, the major RISC processors are likely to become almost entirely in-house devices for their parent system vendors. Outside users will slowly drift away, to either x86 or the Intel/HP architecture. PowerPC may pick up some new system vendors as Mac OS proliferates; improved PowerPC performance would also help. In general, RISC chips will remain viable and interesting devices, but their commercial opportunities in general-purpose computers are becoming limited. Future growth lies in emerging consumer devices. ♦

