VIEWPOINT

Escape from the Temple of Doom

By Linley Gwennap

Last issue, John Wharton gave his opinion on why RISC is doomed. In this article, our new Senior Editor Linley Gwennap makes a case for the defense.

The RISC vs. CISC War is over and RISC won. The RISC doom-mongers should keep selling their 386 clones and IBM mainframes as long as they can, and probably make some money at it. But please, leave the rest of us alone to ponder today's (and tomorrow's) products without having to hear about the "good old days."

I always like to start with dessert—in this case, Mr. Wharton's request for proof of technological superiority. RISC undeniably allows faster clock rates than CISC. The fastest 486 today clocks at 66 MHz (internal), and the P5 will be no faster. MIPS today ships 100-MHz R4000s, and by the time the P5 ships, PA-RISC will have 100-MHz PA7100s and the R4000 may reach 150 MHz. Another instructive comparison is DEC's NVAX CPU, at 80 MHz, and the 21064 Alpha CPU, which runs at 150-200 MHz using the same IC process. Intel's chimerical 100-MHz 486 could never withstand the rigors of real-world temperatures and voltages and is a sideshow, not a product.

Of course, clock rates don't always translate into performance, so let's look at some benchmarks. Table 1 compares the SPEC92 ratings of various RISC and CISC processors that are shipping today or will be in the next six months. Some numbers are estimates, but they show that the souped-up 486DX2-66 lags behind the R4000, SuperSPARC, IBM POWER, and HP "Snakes" in integer performance. The P5 will lag behind faster versions of the R4000, SuperSPARC, POWER, PA-RISC, and Alpha, a new RISC entrant.

Processor, Internal Clock Rate	SPECint92	SPECfp92
IBM POWER, 50 MHz	42.0	85.6
HP Snakes, 66 MHz	48.1	75.0
MIPS R4000, 100 MHz	61.7	63.4
SuperSPARC, 40 MHz	52.6	64.7
i486DX2, 66 MHz	32.4	16.1
HP PA7100, 100 MHz	70+	130+
Alpha 21064, 150 MHz	70?	120?
MIPS R4000, 150 MHz	90	95
SuperSPARC, 50 MHz	65	80
Intel P5, 66 MHz	60?	60?

Table 1. Processor performance comparison.

In floating point performance, the 486 is a speck in the distance behind the leading RISC chips, and the P5 will close the gap to merely half the speed of the leaders. Contrary to the wishful thinking of CISC flag-wavers, floating point is a valid metric for this discussion. RISC techniques such as load-store architecture, simple memory addressing, and plenty of registers work as well in the floating-point unit as they do on the integer side. The fastest chips use superscalar and/or superpipelined designs to improve their floating-point performance, two techniques made easier by the single size and simple execution model of RISC instructions.

Some people may yawn at these numbers. After all, RISC isn't an order of magnitude better, or even a factor of two. Processor architecture is, however, only one factor in overall system performance. Circuit design, IC process, the cache, and memory system all affect performance independently of the RISC/CISC dichotomy. The key point is that *all* popular RISC chips are ahead of Intel's chips in *both* integer and floating-point performance, despite Intel's incredible R&D budget. The table doesn't include less-popular CISC chips such as the x86 clones or the 680x0, but these would rate even lower than the Intel chips.

By the way, Joy's law hasn't fallen off track—SPARC has. The original SPARCstation 1, released in mid-1989, had a SPECmark89 rating of about 8. Just four years later, DEC, HP and probably IBM will be shipping machines well above the target of 128 SPECmarks set by Joy's law (performance doubles every year). Yes, these will be RISC systems.

And then, of course, there's the cost issue. Let's not confuse manufacturing cost with selling price. It is generally agreed that chip cost relates most directly to die size. At 165 mm^2, the i486 is a bit smaller than the PA7100 (196 mm^2) or the R4000 (184 mm^2) but offers much less performance. Note that all of these chips use similar 0.8-micron CMOS processes. Looking toward the future, the P5 will be a monster chip at 262 mm^2, larger than any of the popular RISC chips, and again will offer less performance. Like CISC, RISC also comes in small packages; the tiny ARM chip crams a RISC CPU and 4K of cache (although no FPU) into just 80 mm^2. RISC delivers on its promise to provide not just higher performance but better cost/performance.

RISC Victories

RISC has seized several key markets. First to switch was the workstation market. Originally, Apollo's 680x0 systems owned this market, later followed by Sun's original products, also based on the 680x0, and Hewlett-Packard's systems using the same microprocessors. Workstation customers need the best possible performance to solve complex technical problems, and RISC systems provide this power. In particular, the immense floating-point advantage of RISC processors is critical for both scientific calculations and high-end graphics. To take advantage of RISC, Sun created SPARC, DEC pushed MIPS boxes, and IBM made a big splash with POWER. Apollo invented PRISM, but too late to save itself from being absorbed by HP, which then used PA-RISC to rejuvenate its flagging workstation business. Today, of the top five workstation vendors, only DEC is selling a significant number of CISC systems, and these VAXstations are scheduled to be replaced by Alpha products within the year. HP, Sun, and IBM will each sell several billion dollars of RISC systems this year.

Next to fall were CISC minicomputers. In this market, HP led the way in rolling its old CISC line, the HP 3000, over to a RISC architecture. Pyramid has been very successful, first with its proprietary RISC and then with MIPS processors. Tandem is rolling its entire product line to MIPS chips. One of Data General's few competitive product lines is its 88100-based server line. Around the outskirts of the marketplace lie the carcasses of companies that didn't make the switch in time: Burroughs, Prime, Wang, and others.

The two major holdouts in this area are traditionalists DEC and IBM. Yet even these behemoths are starting to move quickly in the RISC direction. DEC has announced its intention to move its entire VAX product line, representing billions of dollars of annual revenue, to Alpha by mid-decade, and its designers have included architectural hooks to ease the transition.

IBM has so far tried to restrain its POWER systems to the technical market, yet over half of its RS/6000 units sell into commercial accounts. Customers demand the RISC systems because of their superior price/performance. For example, both the RS/6000 Model 970 and the AS/400 E80 yield 100 transactions per second (TPC-A), but the CISC system is priced at $640,000 while the RISC system lists for under $150,000 with equivalent disk and memory added. It is only a matter of time before IBM ports the AS/400 operating system to POWER and migrates its customer base to RISC, just as HP has done and DEC plans to do.

The mainframe market continues to be an IBM-compatible market. As such, it cannot be converted to RISC by definition. In reality, much of what used to be done on mainframes (and minicomputers) has migrated to what are now called "servers," a market that is dominated by the RISC products discussed previously.

For example, HP recently announced a PA-RISC "Corporate Business Server" as part of a mainframe-downsizing initiative. The machine itself is about the size of the water-recirculation unit for an IBM mainframe and costs less to buy than the support contract for the mainframe. Several third-party vendors provide emulation and conversion tools for customers who have lots of old IBM software locked up in "dusty decks." Dusty DEC will refurbish its VAX 9000 line with Alpha processors and take another run at the mainframe market. Even Big Blue may someday build cheaper, faster POWERframes.

Microprocessors and Microsystems

All the major microprocessor vendors have started RISC product lines. Intel's i860 and i960, AMD's 29000, Motorola's PowerPC (second try), and TI's SuperSPARC have so far been fairly successful, although some required repositioning to the embedded control market. These products, along with other SPARC and MIPS chips, have sold well in embedded applications that need plenty of horsepower, such as graphics coprocessors, Postscript printers, and X-terminals. Most of the RISC chip vendors have not targeted the lower-cost, high-volume controller market, but as these low-end applications migrate to higher performance levels, many will seek the advantages of RISC.

The one market that RISC has so far been unable to crack is the personal computer market. Like mainframes, PCs have been considered an IBM-compatible market. Most users do not have source code for their applications and thus cannot switch to RISC. Even the software vendors have been reluctant to port their applications to RISCy UNIX platforms.

The markets in which RISC has done well share a willingness of users (and software vendors) to port applications. Minicomputer customers were originally weaned from mainframes by porting their software, and often had to port from one product family to the next (an old IBM trick) before ending up on a RISC platform. The workstation market, which took off about the same time that RISC did, never had a large installed base of CISC systems. Embedded controllers run a single set of software that the vendor is often willing to port for a performance advantage. The slow start of RISC in other areas is not due to any technical deficiencies, but rather the incredible inertia of a large software base.

That being said, RISC is about to make tremendous inroads into the personal computer market due to several factors. First, Apple has decided to move its entire product line to PowerPC. This alone will give RISC a 10-20% foothold in the general-purpose processor market. Another factor is the expected growth in handheld com-

puters. These devices, freed from the tyranny of DOS, will be able to take advantage of RISC processors. Apple, for example, will use ARM in its Newton product, and GO will offer its PenPoint O/S on the Hobbit chip, another low-cost RISC solution. Explosive growth in the sales of these small computers could give RISC another big chunk of the PC market.

A third factor is the replacement of DOS on the desktop with Windows NT. If NT does well, all the major RISC vendors will probably join MIPS and DEC in porting NT to their systems. (The IBM/Apple coalition may be an exception if they stick with Macintosh O/S and move to Taligent.) NT is designed from the ground up to be portable and to make it much easier for applications to be ported. ISVs, no longer concerned about the foibles of UNIX, will be able to offer their products on several platforms. RISC vendors will sell systems at PC price points. With such open competition, RISC-based NT systems could grab another 10%–20% of the PC market due to their price/performance advantage.

RISC has clearly demonstrated that it provides a significant performance advantage over CISC. This is true despite Intel spending hundreds of millions of dollars to prop up the x86 architecture. This is even true when RISC chips are late (e.g. SuperSPARC) or done on a relatively small budget (e.g the R4000).

In ten years, RISC has moved out of academia and taken over several key markets by mortally wounding several CISC architectures. Over the next decade, RISC will make additional inroads into the low-cost embedded market, the high-end mainframe market, and the personal computer market. Some patience will be required while ancient software finally disintegrates, but even the legendary Arthur didn't become king until his second decade. ♦

