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PowerPC Becomes Best-Selling Desktop RISC

PowerPC Sales Surpass SPARC's—Alpha Retains Performance Lead

by Linley Gwennap

At this time of year, we look back on the previous 12 months and forward at the year to come. Our coverage includes general-purpose RISC chips and embedded processors. Our next issue will cover the x86 market and multimedia processors. Happy New Year!

During the past year, the phrase "RISC PC" went from an oxymoron to the most powerful force in the RISC processor market. Apple's Power Macintosh arrived in March, cutting RISC system prices to the previously unthinkable $2,000 price point and propelling PowerPC volumes well beyond those of any other desktop RISC processor. Other system and processor vendors are scurrying to try to duplicate Apple's success.

PowerPC's initial strength has forced Intel to stop snickering about RISC PCs and start worrying. Perhaps the biggest sign of this concern is the megadeal between Intel and HP announced last summer. The companies plan to develop a new "post-RISC" architecture to replace both x86 and PA-RISC, setting the stage for a new round of architecture wars at the end of this decade.

Few new RISC processors were announced in 1993, but vendors made up for that during the past year by rolling out the PowerPC 604, SuperSparc-2, and the PA-7200, along with a slew of clock-speed upgrades. The major vendors saved their best for last, getting together last fall at the Microprocessor Forum to unveil five next-generation devices that push the high end of RISC performance (and complexity) to new levels. None of these devices, however, is currently shipping, and only Digital's 21164 is expected before 3Q95.

To commemorate the best and the worst of 1994, we present our third annual RISCie awards.

PowerPC Scores on Opening Drive

The PowerPC 601 takes the award as the **Best-Selling RISC Processor**. Although IBM raised eyebrows in July by claiming that it had already shipped one million 601 processors, we estimate that about 800,000 PowerPC systems shipped in 1994. Nearly all contain a 601 processor, and more than 90% are Power Macintosh systems. This sales figure is roughly four times the unit volume of SuperSparc, last year's sales leader.

While the 601 carried the load, IBM and Motorola made first volume shipments of both the 603 and 604 PowerPC chips. The 603 earns the **Phantom of the Opera** sobriquet for achieving "volume" shipments in 3Q94 without any volume customers; even today, the 603 is shipping only in what is essentially a development system from Motorola. That situation will change dramatically starting in 2Q95, when Apple begins shipping 603-based Power Macintosh systems.

Apple's recent decision to license its Mac OS should give a big boost to PowerPC's prospects. Although the architecture continues to lead the RISC field in **Most Operating Systems Supported**—having added Novell NetWare, along with the AS/400 operating system, in the past year—open availability of Mac OS should let most desktop software vendors focus on that single platform for PowerPC. While providing little immediate threat to Intel's hegemony, Apple and its licensees could take a few points of market share from the x86 over the next couple of years.

This battle is already heating up. IBM earns a penalty flag for **Bogus Advertising** for its ad that shows RISC (i.e., PowerPC) performance increasing at an exponential rate while CISC (i.e., x86) performance levels off. Intel responds by saying that its post-RISC architecture will be clearly superior to a mere RISC design like PowerPC. With Intel running Pentium ads on national TV, can PowerPC commercials be far behind?

PowerPC also receives the **Biggest Bandwagon** award, as major vendors such as Canon, Toshiba, and Olivetti (through an investment in startup Power Com-

puting) have hopped aboard. Samsung and Acer are rumored to be next in line. Lost in the commotion was an announcement that IBM has brought down the curtain on POWER; all its future devices will implement the PowerPC architecture.

In 1995, Motorola and IBM should begin shipping the 620 processor, winner (or loser) of the **Biggest Disappointment** award. The 620 was supposed to be PowerPC's high-end killer CPU, but it trails all other next-generation RISCs in projected performance and is barely faster than a 604 at the same clock speed. The companies are now trying to find ways to quickly boost the 620's relatively poor 133-MHz clock frequency. The 601, 603, and 604 will also see speed upgrades in 1995.

Watch for the debut of the much-rumored 615 chip in 1995. Due to begin shipping toward the end of the year, the 615 will combine a fast PowerPC core with hardware that accelerates x86 instruction execution, making it an early pick for next year's Most Innovative Product award. IBM is also working on a multichip device currently known as the PowerPC 630, which could debut in late 1995 or 1996.

Alpha Leads Quarterback Ratings

Digital's Alpha is a star quarterback on a losing team. The company's losses are measured in dollars, and lots of them: $5.8 billion over four years, $1.1 billion (–27%) in system revenue over the past year alone.

But the microprocessors look great. Through compiler enhancements and the fruition of the 21064A, Alpha retained its performance lead throughout 1994 and, for the third year running, wins the award for the **World's Fastest Microprocessor (shipping)**. As Table 1 shows, the 275-MHz 21064A delivers 200 SPECint92 and 291 SPECfp92.

Digital's next-generation chip, the 21164, is the **World's Fastest Microprocessor (sampling)** and is likely to maintain Alpha as the performance leader throughout 1995 as well, as Figure 1 shows. At 300 MHz, the 21164 delivers about 330 SPECint92 and more than 500 SPECfp92. By focusing on a simpler design than its competitors have, Digital will be the first to bring a processor of this caliber to market.

The 21164 tops the charts in a number of other categories as well, including on-chip cache size (112K), transistor count (9.3 million), and power dissipation (50 W), as Table 2 shows. It also takes a penalty for **Highest List Price**, an unsportsmanlike $2,937.

At this price, the 21164 appeals to customers like Cray, but Digital will find few other takers, as Alpha wins this year's **Empty Bandwagon** award. Olivetti has apparently jumped to the PowerPC bandwagon, and Kubota has dropped its line of Alpha systems due to poor sales. This leaves Cray and a handful of tiny system vendors as Digital's only Alpha customers.

Mitsubishi confirmed that it will second-source Dig-

Processor	DECchip 21064A	MIPS R8000	HP PA-7150	MIPS R4400SC	Intel Pentium	Ross HyperSparc	PowerPC 601	TI SuperSparc	TI S'Sparc-2
System	Digital 2100 4/275	SGI Power Challenge	HP 9000 735/125	SGI Challenge	Intel XPress	Sun SS-20 Model HS11	RS/6000 Model 41T	Sun SS-20 Model 61	Sun prototype
Clock Rate	275 MHz	75 MHz	125 MHz	200 MHz	100 MHz	100 MHz	80 MHz	60 MHz	90 MHz
Cache (on/off-chip)	32K/4M	32K/4M	none/512K	32K/4M	16K/512K	8K/256K	32K/512K	36K/1M	36K/1M
espresso	174.6	80.8	120.1	110.4	89.7	97.8	76.9	69.5	114.1
li	176.9	114.8	153.0	137.1	133.5	126.5	103.8	77.3	174.4
equtott	297.3	159.4	177.4	178.3	107.8	161.8	103.8	127.0	215.7
compress	114.0	77.8	90.8	92.6	60.9	54.5	62.4	42.1	83.2
sc	415.6*	194.4	292.3*	264.8*	279.6*	150.0	119.8	115.9	290.4*
gcc	147.6	86.9	128.8	117.3	93.3	79.6	75.4	62.2	103.4
SPECint92	200.1	111.7	149.4	140.7	112.7	104.5	88.1	76.9	148.5
spice	143.5	85.2	106.8	100.6	64.3	73.4	65.5	66.4	98.4
doduc	218.8	157.6	200.0	118.1	84.2	117.0	77.8	96.8	125.7
mdljdp2	229.4	250.5	263.6	183.0	98.5	186.6	113.3	103.1	144.1
wave5	172.9	180.5	171.3	107.7	57.1	100.0	60.0	68.4	105.1
tomcatv	464.9	679.5	158.7	197.5	72.8	118.8	124.7	86.9	134.5
ora	268.8	236.3	365.5	150.9	98.0	256.8	74.3	191.1	224.2
alvinn	630.3	792.8	325.8	166.5	165.0	256.3	210.1	209.3	341.8
ear	904.3	569.2	468.8	289.8	225.9	179.3	173.7	113.3	193.5
mdljsp2	109.1	115.9	127.4	94.2	47.4	91.3	63.2	50.3	69.2
swm256	289.3	361.8	89.1	110.1	43.2	70.9	80.4	49.5	76.3
su2cor	379.4	516.0	205.1	139.8	64.4	159.1	115.5	136.0	183.2
hydro2d	337.4	484.1	194.9	151.9	84.0	122.8	79.0	93.7	132.6
nasa7	336.7	608.7	135.5	158.5	58.5	96.6	110.6	110.6	174.1
fpppp	259.9	279.6	345.9	123.4	115.4	110.4	128.3	121.3	180.4
SPECfp92	291.1	310.8	201.3	142.7	81.8	127.6	98.7	98.1	143.1

Table 1. DIgital's 275-MHz 21064A holds the integer performance lead, but the R8000 leads for floating point. Except for SuperSparc-2, these processors are currently shipping. *indicates use of new "curses" package to increase SPECint92 score. (Source: vendors)

ital's low-end 21066 chip but has delayed any volume shipments until 2H95, waiting to see how the market develops. Like the 603, the 21066 is tagged as a **Phantom of the Opera**; until November, even Digital itself had not announced a 21066-based system.

Looking ahead, we see Digital delivering 21164 chips at 300 MHz in 1Q95 and pushing the clock rate to 350–400 MHz by the end of the year. The 21066A will begin shipping at 233 MHz in early 1995, shoring up Alpha's low end. We expect that Digital will double its Alpha system revenue in 1995 but still lose overall as its MIPS and VAX businesses continue to collapse. The company should make some headway in the RISC PC market, mostly in niche technical markets, but Alpha processors will see little action outside of Digital.

MIPS Struggles to Cross Midfield

The MIPS camp has its own outstanding processor, aimed at the midrange instead of the high end. The R4700 wins the **Editor's Choice** award as the best RISC microprocessor design of 1994. This device is a simple derivative of the original Orion (R4600) design, but the R4700 reveals the full potential of Orion. The new chip, at 175 MHz, is rated at 130 SPECint92 and 100 SPECfp92, making it the **Fastest Low-End Processor** in Table 3.

Ironically, Orion is the only mainstream MIPS processor not designed by MIPS Technologies. Quantum Effect Design (QED) created the R4700, which is sold by IDT, Toshiba, and NKK. The chip's simple design allows fast clock speeds and a small die: just 73 mm^2, making it the **Smallest RISC Processor** for desktop systems. With an estimated manufacturing cost of $35, the R4700 offers exceptional cost/performance.

Silicon Graphics (SGI), the leading vendor of MIPS-based systems, has revamped its Indy workstation line to take advantage of the price/performance of Orion. The company is still struggling, however, to match the high-end performance of its competitors. It earns a flag for **Bogus Advertising** by running ads with the tag line "MIPS—The Fastest Processors on the Planet™." It isn't clear what planet these guys are on, as here on Earth the 200-MHz R4400 trails the Alpha 21064A, PowerPC 604, and PA-7150 in performance.

Hopes for closing this performance gap lie with the next-generation R10000 (code-named T5). MIPS Technologies earns a second **Bogus Advertising** penalty for running ads headlined "The R10000—First in Real Performance." Given that the chip has yet to see silicon (and system shipments are not expected until 4Q95), "First in Simulated Performance" would be more accurate, if somewhat less compelling.

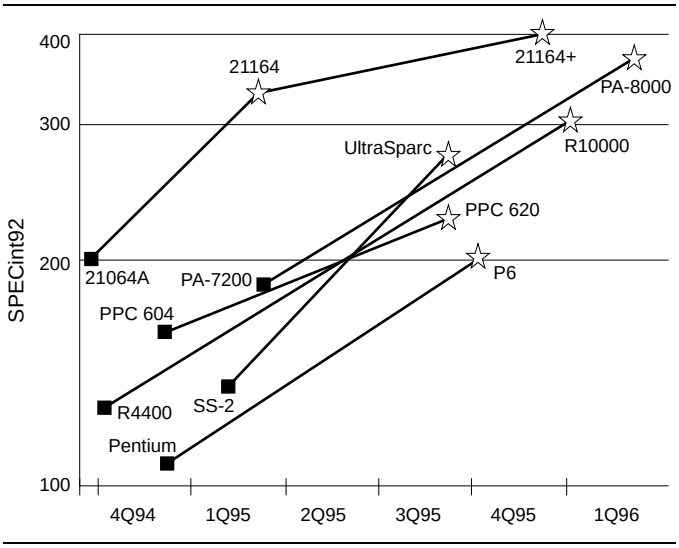

Figure 1. As vendors deploy their next-generation processors (shown by stars) in 1995, high-end performance will increase dramatically. The 21164 should keep Alpha in the performance lead, but new MIPS and PA-RISC processors could close the gap.

Despite Orion's advantages, MIPS has been losing momentum in the RISC PC market, mainly due to a lack of application software. We're flagging the MIPS camp for **Lack of Commitment**: no new PC vendors of note have signed up, and Acer's support is wavering. NEC is a strong backer but is hindered by lack of access to Orion.

	R10000	PPC 620	UltraSparc	21164	PA-8000
Clock Speed	200 MHz	133 MHz	167 MHz	300 MHz	200 MHz*
Cache Size	32K/32K	32K/32K	16K/16K	8K/8K/96K	none
Issue Rate	four	four	four	four	four
Function Units	five	six	nine	four	six
Predecode Bits	4 bits	7 bits	4 bits	none	5 bits
Rename Regs	32 int, 32 fp	8 int, 8 fp	none	none	56 total
Branch History	512 × 2	2K × 2	512 × 2	2K × 2	256 × 3
Out of Order	32 instr	16 instr	none	6 loads	56 instr
Ext Cache Cntl	on chip	on chip	on chip	on chip	on chip
Sync SRAM	yes	yes	yes	optional	yes
Glueless MP	yes	yes	yes	yes	yes
Power Usage	30 W	30 W	30 W	50 W	30 W*
IC Process	0.5-micron	0.5-micron	0.5-micron	0.5-micron	0.5-micron
Metal Layers	four	four	four	four	four
Logic Transistors	2.3 million	2.2 million	2.0 million	1.8 million	2.5 million*
Total Transistors	5.9 million	6.9 million	3.8 million	9.3 million	2.5 million*
Package Type	527-pin CPGA	625-pad CBGA	521-pin CPGA	499-pin CPGA	700-pin* CPGA
Die Size	298 mm^2	311 mm^2	315 mm^2	298 mm^2	250 mm^2*
Est Mfg Cost	$320*	$380*	$420*	$430*	$380*
First Silicon	4Q94 (est)	7/94	10/94	2/94	1Q95 (est)
Volume Parts	4Q95 (est)	3Q95 (est)	3Q95 (est)	1Q95 (est)	1Q96 (est)
SPECint92 (est)	>300 int	225 int	275 int	330 int	375 int*
SPECfp92 (est)	>600 fp	300 fp	305 fp	500 fp	500 fp*

Table 2. Next-generation RISC processors have similar microarchitecture designs but differ in clock speed, performance, and schedule. (Source: vendors except *MPR estimates)

With SGI still far behind Sun and HP in the workstation market, desktop prospects appear limited for MIPS.

The architecture is doing much better in nontraditional markets, including video servers and set-top boxes *(see **081703.PDF**)*. We see MIPS, in the fine tradition of AMD's 29000 and Intel's i960, as the RISC architecture **Most Likely to Abandon the Desktop**.

SPARC Plays Prevent Defense

Sun got off to an early lead in RISC volumes but has seen its growth slow in recent years as the once-hot workstation market has cooled. Despite a flurry of announcements, Sun's microprocessor efforts have been emphatically ineffective: over the past 12 months, the company's high end has gone from the 60-MHz SuperSparc to…the 60-MHz SuperSparc, earning it a penalty for **Illegal (Lack of) Motion**.

One bright spot for SPARC was the second coming of HyperSparc. While SuperSparc fiddled, Ross took advantage of its new status as a Fujitsu subsidiary by moving its design to Fujitsu's 0.5-micron CMOS process, boosting the clock speed by 50%. HyperSparc takes the award for **Best Packaging**: an elegant little 131-pin multichip module (MCM) contains the two processor chips along with 256K of cache, reducing overall cost and improving performance. At 100 MHz, the new HyperSparc outruns the 60-MHz SuperSparc, as Table 1 shows.

Sun will unleash a one-two performance punch in 1995, leading with SuperSparc-2 in the first quarter. At 90 MHz, the chip should move SPARC out of the embarrassing sub-Pentium performance range. In 3Q95, the company hopes to deploy the first UltraSparc systems. This next-generation processor takes the award for **Largest Die Size** at 315 mm^2 (although it is well behind Cyrix's 394-mm^2 M1, which is not a RISC chip). Initial reports are that UltraSparc is looking good to meet its clock-speed target of 167 MHz although, like SuperSparc-2, it is about six months behind schedule.

Sun's midrange continues to be covered by MicroSparc-2, currently shipping at 85 MHz. Look for parts at 100 MHz or even faster in early 1995. The coming year should also see the debut of two SPARC processors that have had elephantine gestational periods: Hal Computer's PM-1 and Metaflow's Thunder. Both are likely to trail UltraSparc in performance and exceed it in cost, earning them the **Too Little, Too Late** award.

SPARC continues to sit on the cusp of architectural survival. It's clearly in a better position on the desktop than Alpha, MIPS, or PA-RISC, but that's not saying much. SPARC system vendors such as Toshiba and Tatung are offering PowerPC systems as a hedge strategy, and even Sun itself is hedging by porting Solaris to x86 and PowerPC. The company's "go slow" attitude toward RISC PC standards, such as Windows NT and PCI, is keeping it out of that market. A year ago, we thought that Sun's strategy was "confused"; this year, we see no improvement.

Processor	MIPS R4600	MIPS R4700	PowerPC 603	PowerPC 601	HP PA-7100LC	SPARC MS-2	DECchip 21066A	Intel Pentium
Pipeline Frequency	150 MHz	175 MHz	80 MHz	100 MHz	100 MHz	85 MHz	233 MHz	90 MHz
Number of Pipe Stages	5 stages	5 stages	5 stages	5 stages	5 stages	5 stages	7 stages	5 stages
Max Instructions per Cycle	1 issue	1 issue	3 issue	3 issue	2 issue	1 issue	2 issue	2 issue
Max Load/Stores per Cycle	1 mem	1 mem	1 mem	1 mem	1+ mem(2)	1 mem	1 mem	2 mem
Max Integer Math per Cycle	1 int	1 int	1 int	1 int	2 int	1 int	1 int	2 int
Max FP Math per Cycle	1 FP	1 FP	1 FP	1 FP	1 FP	1 FP	1 FP	1 FP
On-Chip I-Cache	16K	16K	8K	32K	1K	16K	8K	8K
On-Chip D-Cache	16K	16K	8K	unified	none	8K	8K	8K
Peak On-Chip Cache B/W	2,400 MB/s	1,867 MB/s	1,280 MB/s	3,200 MB/s	800 MB/s	1,360 MB/s	3,733 MB/s	3,600 MB/s
Peak Off-Chip Cache B/W	600 MB/s	600 MB/s	640 MB/s	640 MB/s	800 MB/s	none	333 MB/s	480 MB/s
Integrated System Logic	none	none	none	none	cache cntl, memory	memory, SBus	cache cntl, mem, PCI	none
IC Process Type	CMOS	CMOS	CMOS	CMOS	CMOS	CMOS	CMOS	BiCMOS
Feature Size (drawn)	0.64 µm	0.60 µm	0.50 µm	0.50 µm	0.80 µm	0.50 µm	0.50 µm	0.50 µm
Number of Metal Layers	3 metal	3 metal	4 metal	5 metal	3 metal	3 metal	4 metal	4 metal
Transistor Count	1,850,000	1,850,000	1,600,000	2,800,000	800,000	2,300,000	1,747,000	3,300,000
Die Area	77 mm^2	73 mm^2	85 mm^2	74 mm^2	196 mm^2	233 mm^2	161 mm^2	163 mm^2
Estimated Mfg Cost*	$35	$35	$50	$70	$115	$145	$125	$125
Package	208 pin MQUAD	208 pin MQUAD	240 pin CQFP	304 pin CQFP	432 pin PGA	321 pin PGA	287 pin PGA	296 pin PGA
SPECint92	110 int	~130 int	~75 int	~105 int	101 int	64 int	~94 int	101 int
SPECfp92	83 fp	~100 fp	~85 fp	~125 fp	137 fp	55 fp	~110 fp	74 fp
1K List Price (at max freq)	$390	n/a	$195	$399	n/a(3)	$449	$396	$587
Vendor	IDT(1)	IDT(1)	Moto, IBM	IBM, Moto	HP	Fujitsu, Sun	Digital	Intel
First Volume Shipments	1Q94	~1Q95	4Q94	4Q94	1Q94	2Q94	~1Q95	2Q94

Table 3. Many low-cost RISC processors deliver performance similar to that of Pentium but at a lower price. The 603 and MicroSparc-2 fall behind Pentium's performance, but at least the 603 offers a much lower price. (1) also sold by Toshiba and NKK (2) can issue two memory operations only if they access the same doubleword (3) not available on the merchant market (Source: vendors except *MPR estimates)

HP Makes a Stunning Play

Last year, we designated HP as the Most Likely to Get a Hernia while carrying its architecture. This year, HP decided to get some help, turning to the strongest vendor out there: Intel. Starting in 1998 or so, the two companies expect to roll out processors using a new instruction set, probably based on very long instruction word (VLIW) technology, that retains compatibility with both x86 and PA-RISC. This move earns HP the award for **Boldest Strategic Decision**.

If HP can avoid suffering the fate of Intel's long line of ex-partners, it will be able to unify its PC and RISC product lines around a single industry-standard architecture. HP will retain the right to design and manufacture its own processors while ensuring the long-term viability of its architecture. Finally, a new instruction set will make it easier for HP (and Intel) to build processors that outperform older RISC designs.

In the meantime, however, HP has to survive with PA-RISC. Like Sun, HP announced a variety of processors in 1994 that have yet to begin shipping. Early in the year, the company did ship its PA-7150, briefly challenging Digital for the performance lead, but since then it has again fallen behind in performance.

The company is putting the finishing touches on its PA-7200 processor, due to ship in 1Q95. This device wins the **Most Innovative Product** award for its unique "assist" cache that greatly reduces thrashing in the large, external data cache. The PA-7200 also includes a well-engineered solution for glueless multiprocessing, a feature adopted by all next-generation RISC devices.

The PA-7200 will be HP's high end throughout 1995. In early 1996, the company expects to begin shipping the PA-8000, unveiled at this year's Microprocessor Forum. This next-generation device could be worth the wait: it earns the **Most Feature-Filled Chip** award and aims to deliver nearly 400 SPECint92. The PA-8000 will be the last new PA-RISC core for HP, tiding it over until the first fruits of the Intel deal appear.

HP's deal with Intel leaves its other PA-RISC partners in the lurch. PA-RISC may continue to be viable for embedded applications, but once HP stops developing PA-RISC processors and switches over to the new architecture, there seems little reason for vendors such as Samsung and Hitachi to continue their PA-RISC plans. Hitachi has already taken a POWER/PowerPC license, although its immediate plans focus on mainframes, and Samsung also is considering PowerPC. These moves could leave the Precision RISC Organization with an **Empty Meeting Table**.

Other Processors Ride the Bench

It's hard to find evidence of other RISC processors in the general-purpose systems market. Intergraph finally pulled the plug on its Clipper family, relying instead on x86 and SPARC processors. Motorola's 88000 is on life support at Data General, which stubbornly re-

Processor	PowerPC 604	MIPS TFP	MIPS R4400	HP PA-7200	Digital 21064A	Super-Sparc-2	Hyper-Sparc	Intel Pentium
Pipeline Frequency (max)	100 MHz	75 MHz	200 MHz	140 MHz	275 MHz	90 MHz	100 MHz	100 MHz
Number of Pipe Stages	6 stages	5 stages	8 stages	5 stages	7 stages	4 stages	6 stages	5 stages
Max Instructions per cycle	4 issue	4 issue	1 issue	2 issue	2 issue	3 issue	2 issue	2 issue
Max Load/Stores per cycle	1 mem	2 mem	1 mem	1 mem	1 mem	1 mem	1 mem	2 mem
Max Integer Math per cycle	2 int(1)	2 int	1 int	2 int	1 int	1 int	1 int	2 int
Max FP Math per cycle	1 FP	2 FP	1 FP	1 FP	1 FP	1 FP	1 FP	1 FP
On-Chip I-Cache	16K	16K	16K	none	16K	20K	8K	8K
On-Chip D-Cache	16K	16K	16K	2K	16K	16K	none	8K
Peak On-Chip Cache B/W	1,600 MB/s	2,400 MB/s	3,200 MB/s	1,120 MB/s	4,400 MB/s	2,160 MB/s	800 MB/s	4,000 MB/s
Peak Off-Chip Cache B/W	528 MB/s	1,200 MB/s	1,600 MB/s	2,240 MB/s	1,100 MB/s	720 MB/s	800 MB/s	533 MB/s
Branch History Table	512 × 2	1024 × 1	none	none	4096 × 2	none	none	256 × 2
Total TLB Entries	264	384 entries	48 entries	136 entries	48 entries	80 entries	64 entries	96 entries
IC Process Type	CMOS	CMOS	CMOS	CMOS	CMOS	BiCMOS	CMOS	BiCMOS
Feature Size (drawn)	0.50 µm	0.70 µm	0.50 µm	0.55 µm	0.50 µm	0.6 µm	0.50 µm	0.50 µm
Number of Metal Layers	4 metal	3 metal	2 metal	3 metal	4 metal	3 metal	3 metal	4 metal
Transistor Count	3,600,000	3,430,000(2)	2,200,000	850,000	2,800,000	3,100,000	1,700,000(2)	3,300,000
Die Area	196 mm²	596 mm²(2)	148 mm²	210 mm²	164 mm²	299 mm²	327 mm²(2)	163 mm²
Estimated Mfg Cost*	$140	$670(2)	$140	$220	$160	$260	$180(5)	$125
Package	304 pin CQFP	2 × 591 pin PGA	447 pin PGA	540 pin PGA	431 pin PGA	313 pin PGA	121 MCM-C	296 pin PGA
SPECint92	~160 int	109 int	141 int	180 int*	200 int	148 int	103 int	112 int
SPECfp92	~165 fp	311 fp	143 fp	250 fp*	291 fp	143 fp	127 fp	82 fp
1K List Price (at max freq)	$549	n/a(3)	$1,200(4)	n/a(3)	$1,188	$999	$2,789(5)	$935
Vendor(s)	IBM, Moto	Toshiba	IDT(4)	HP	Digital	TI, Sun	Fujitsu	Intel
First Volume Shipments	4Q94	2Q94	4Q94	1Q95	3Q94	1Q95	4Q94	2Q94

Table 4. Key parameters for high-end RISC processors and, for comparison, Pentium. (1) two simple integer plus one complex integer (2) includes two chips (3) not available on the merchant market (4) IDT price; price varies among IDT, Toshiba, and NEC (5) includes complete processor module (Source: vendors except *MPR estimates)

fuses to switch to a more mainstream architecture. Motorola itself has already moved on to PowerPC, making the 88000 the **Most Likely Casualty** for 1995.

Software Is the Key

The battle among the complex, powerful next-generation RISC chips will be an exciting one to watch in 1995. A more meaningful competition, however, is at the low end, as RISC vendors struggle to establish themselves in the high-volume PC market. The successful vendors will achieve much greater sales and be assured of survival into the next decade. The losers will see RISC and Pentium PCs eat away at lucrative workstation sales and be banished into server oblivion (or worse).

The key factor is getting mainstream software onto the new platforms. The PowerPC/Mac OS combination has a clear advantage in this regard. So far, Alpha is doing best among the RISC architectures in gaining applications for Windows NT, but PowerPC is off to a fast start there as well. HP has given up on using PA-RISC to compete with PCs, instead relying on its future Intel-compatible processors to solve this problem.

Without access to the x86 software base, the performance advantage of RISC chips will continue to count for naught in the PC market. Some RISC vendors project that this advantage will increase over time, making their processors ever more attractive. But as x86 processors like AMD's K5 and Intel's P6 adopt RISC design techniques, it will be difficult for the RISC vendors to expand their performance lead. Thus, attracting software will be the key to unlocking the PC market.

One alternative to porting applications is to offer high-speed x86 emulation, as in the PowerPC 615. MIPS Technologies is said to be developing a similar chip, but it probably won't reach the market until 1996. With Pentium and PowerPC dominating the thoughts of software makers, other RISC vendors need to make some dramatic moves to remain competitive in the game. ♦

For more information on general-purpose RISC processors, check out our MicroDesign Resources Technical Library report, RISC on the Desktop*, edited by Linley Gwennap.*

Major RISC Events of 1994

Apple announces first Power Macintosh systems *(see **080401.PDF**)* and plans for open licensing *(see **081602.PDF**)*.

PowerPC 604 powers past Pentium *(see **080501.PDF** and **0814MSB.PDF**)* while 620 fills out PowerPC product line *(see **081402.PDF**)*.

Motorola deploys PowerPC system-logic chip *(see **081202.PDF**)* and software tools *(see **0808MSB.PDF**)* along with first 603 systems *(see **0814MSB.PDF**)*. FirePower deploys 603, 604 systems *(see **0815MSB.PDF**)*.

IBM customizes PowerPC CPU for System/36 *(see **0815MSB.PDF**)* but phases out POWER architecture *(see **0807MSB.PDF**)*. Hitachi *(see **0807MSB.PDF**)* and Toshiba *(see **0814MSB.PDF**)* endorse PowerPC.

Digital leads the pack with 21164 *(see **081201.PDF**)* and, along with Mitsubishi, pushes 21066 to 233 MHz *(see **0816MSB.PDF**)*. Digital ships 275-MHz 21064A *(see **0811MSB.PDF**)* and makes PCI system logic available for Alpha *(see **0801MSB.PDF**)*. Olivetti considers dropping Alpha *(see **0813MSB.PDF**)*.

UltraSparc unleashes SPARC performance *(see **081301.PDF**)*. Sun upgrades with SuperSparc-2 *(see **081505.PDF**)*. MicroSparc-2 moves to 100 MHz *(see **0804MSB.PDF**)*.

HyperSparc hits 100 MHz *(see **0806MSB.PDF**)*, and Sun puts HyperSparc in its workstation line *(see **0815MSB.PDF**)*. Metaflow's Thunder rolls at Hot Chips *(see **0811MSB.PDF**)*. SPARC becomes IEEE standard *(see **0807MSB.PDF**)*.

MIPS R10000 uses decoupled architecture *(see **081403.PDF**)*. R8000 sets SPECfp92 record *(see **0808MSB.PDF**)*. 200-MHz R4400 ready for fall shipments *(see **0808MSB.PDF**)*.

R4600 hits 150 MHz *(see **0809MSB.PDF**)*; NKK becomes third R4600 vendor *(see **0810MSB.PDF**)*. NEC *(see **0805MSB.PDF**)* and NKK *(see **0810MSB.PDF**)* announce system logic for R4x00.

HP allies with Intel on new processor architecture *(see **080801.PDF**)*. Its PA-7100LC hits 100 MHz *(see **0807MSB.PDF**)* while the PA-7150 reaches 125 MHz *(see **0805MSB.PDF**)*.

The PA-7200 enables inexpensive MP systems *(see **080302.PDF**)*, and the PA-8000 combines complexity and speed *(see **081401.PDF**)*.

