

Motorola Begins Sampling PowerPC 601

Aggressively Priced—But Will It Do Windows?

By Michael Slater

Motorola has formally announced its PowerPC 601 microprocessor with aggressive pricing that undercuts its competitors by as much as 50%. Motorola has begun to hint that its sights extend well beyond Apple's RISC Macintosh and IBM (and compatible) workstations, and a port of Windows NT appears to be a likely strategy.

The published prices are \$280 for the 50-MHz version or \$374 for the 66-MHz part, in quantities of 20,000. According to Phil Pompa, Motorola's RISC marketing manager, 1000-piece pricing is less than 25% higher, placing the 50-MHz version under \$350 and the 66-MHz part under \$470 at this often-quoted quantity. As shown in Table 1, these prices are below 486DX2 prices at the same clock rate, but the PowerPC chips deliver much better performance. Motorola has reportedly pitched customers on a "one dollar per SPECmark" target for high-volume pricing that, if achieved, would put the 601 (or its lower-cost successor, the 603) below \$100.

Motorola has not yet released any measured benchmarks for the chip, but it did upgrade its earlier estimates. The new estimates are "greater than 60 SPECint92" and "greater than 80 SPECfp92" at 66 MHz. Previously, Motorola and IBM had estimated 50 SPECint89 and 80 SPECfp89. The '89 and '92 benchmarks are generally comparable on integer ratings, so the upgrade from 50 to 60 represents a 20% boost. The '92 benchmarks generally produce lower floating-point ratings, so holding the FP rating at 80 is, in fact, an increase.

These performance ratings put the 601 near Pen-

tium in integer performance but well ahead in floating-point. It is faster than the MIPS R4000, especially on floating-point code, but falls well short of the newer R4400. The performance is close to SuperSPARC, even considering the latest 50-MHz version of that chip, but significantly slower than Alpha and PA-RISC.

Advanced Manufacturing Reduces Cost

The PowerPC 601 is derived from IBM's RIOS single-chip (RSC) processor used in its RS/6000 Model 220 workstation. It has been extensively modified to increase the cache size and clock rate, change the bus structure to eliminate the separate I/O bus and conform to the bus protocols originally defined for Motorola's 88110, and add the new PowerPC instructions (*see 061401.PDF*). All the original POWER architecture instructions were left intact, so this chip implements a union of the two architectures (i.e., a superset of each).

The three-issue superscalar chip has a 32-Kbyte unified cache and incorporates 2.8 million transistors on a die that is only 11 mm (433 mils) on a side. As Table 1 shows, this is considerably smaller than other processors of comparable performance, and only 50% larger than the much-slower 486DX. This density comes, in part, from the use of a four-level-metal process and IBM's "C4" solder-bump pads that eliminate the need for a separate pad ring, as shown in Figure 1. While these factors increase the wafer cost slightly, this increase is far outweighed by the small die size. Operating from a 3.6V supply (but with 5V-compatible I/O), the 601 consumes 6.5 W at 50 MHz or 9 W at 66 MHz.

	PowerPC 601	486DX2	Pentium	R4000SC	R4400SC	SuperSPARC+	Alpha 21064	PA7100
Clock Rate (internal)	66 MHz	66 MHz	66 MHz	100 MHz	150 MHz	50 MHz	150 MHz	99 MHz
SPECint92	> 60	32.2	64.5	61.7	88 (est.)	65.2	84.4	80.0
SPECfp92	> 80	16.1	56.9	63.4	97 (est.)	83.0	127.7	150.6
External cache	not specified	256K	256K	1M	1M	1M	512K	512K
On-chip cache	32K	8K	16K	16K	32K	36K	16K	none
Die Area	121 mm ²	81 mm ²	294 mm ²	184 mm ²	184 mm ²	256 mm ²	234 mm ²	196 mm ²
Transistors (millions)	2.8	1.2	3.1	1.35	2.2	3.1	1.7	0.85
Process size (drawn)	0.65-micron	0.8-micron	0.8-micron	0.8-micron	0.6-micron	0.7-micron	0.75-micron	0.75-micron
Process type	4-layer metal CMOS	3-layer metal CMOS	3-layer metal BiCMOS	2-layer metal CMOS	3-layer metal CMOS	3-layer metal BiCMOS	3-layer metal CMOS	3-layer metal CMOS
Price (1000s)	< \$470*	\$542	\$995**	\$640***	\$1120***	\$1199	\$1096	not available
Production	3Q93	Now	2Q93 (limited)	Now	3Q93	Now	Now	Now

* Assuming 1000-piece price is less than 25% more than published price of \$374 in 20,000 quantity

** Price not yet announced; estimate based on published reports

*** Toshiba price; price varies among other vendors

Table 1. PowerPC 601 specifications compared to the 486DX2, Pentium, and other RISC processors. Note that faster versions of the Alpha processor are available; this table shows the mainstream desktop version.

The chips will be manufactured by IBM at its Burlington, VT facility, because the design is still based on IBM's proprietary process. Future members of the family are being designed with a jointly developed toolset and will be built by both Motorola and IBM.

Both companies will pursue OEM customers for the 601 and future chips. Unlike IBM's situation with x86 microprocessors, in which its agreement with Intel prevents it from selling chips unless they are part of a board or system, IBM is not barred from selling the chips directly to system makers. IBM lacks a chip-oriented marketing and sales force, which should give Motorola the upper hand in chip sales to new customers, but this will not prevent IBM from competing for known high-volume customers (i.e., Apple).

PowerPC: The Next Generation

Early next year, Motorola expects to deliver first samples of the next two chips in the PowerPC line: the 603 and 604. The 603, scheduled for production in 3Q94, will be significantly less expensive and consume less power; it is intended primarily for portable systems. The original PowerPC family chart shown by Motorola and IBM at the 1991 Microprocessor Forum placed the 603 at a slightly lower performance level than the 601, but recent charts show the 603 as being slightly faster.

The 604, due to go into production in 4Q94, will be roughly twice as fast as the 601 and will replace that chip in the mainstream desktop market. In mid-'94, Motorola plans to begin sampling the high-end 620, which will be the first chip to implement the 64-bit version of the architecture and will nearly double performance over the 604. Production of this high-end part is expected in 1Q95.

In addition to these products, all of which are in development at Somerset (the joint IBM/Apple/Motorola development facility), Motorola has staffed an independent effort to produce designs for specific target markets. One example is Ford's power-train controller, which sources indicate will use a PowerPC chip starting in the second half of the decade. (This design win originally went to the 88000, but Ford quietly switched to the PowerPC after Apple's switch. Motorola and Ford have not yet announced Ford's adoption of PowerPC.)

Motorola declined to comment on what other derivatives it might have in the works. Low-power, highly integrated designs for personal communicators would be one natural opportunity for Motorola to pursue, especially if it could get General Magic to port its Magic Cap operating system from the relatively slow 68300-family processor that it initially will be hosted on.

Many Software Strategies

The PowerPC software strategy has been confusing, partly because of the involvement of multiple companies and partly because all the cards have not yet been

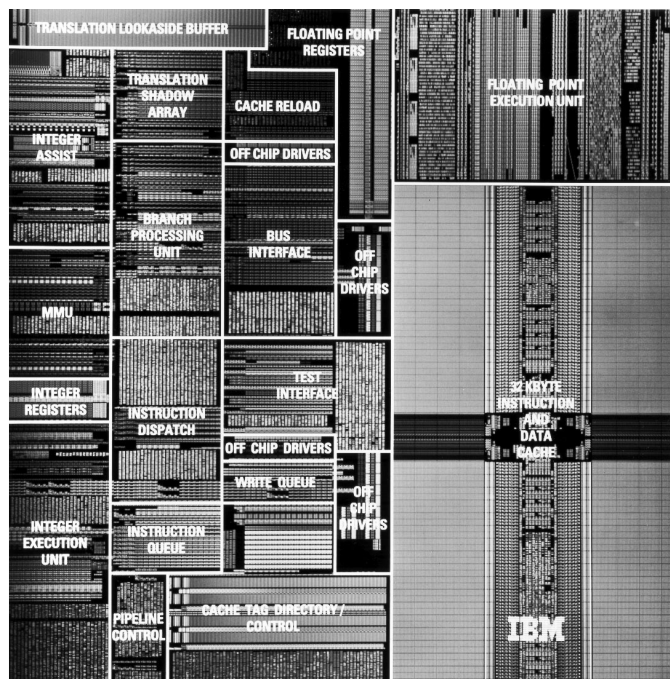


Figure 1. Die photo of the PowerPC 601, which includes 2.8 million transistors on a 121 mm² (187K mil²) die. There is no pad ring; pads are located on the top of circuitry using a fourth metal layer (not shown). Note the off-chip drivers in the middle of the chip.

played. Because PowerPC was announced with Taligent as part of the grand IBM/Apple/Motorola collaboration, many observers associate the two. Taligent may well be the least significant operating system for PowerPC, however, at least in the near term. The collaboration among the three companies is focused on the chips themselves; each company may pursue its own largely separate software strategy.

There are at least five operating systems planned for PowerPC:

- Apple's System 7, which is being ported to PowerPC but will remain proprietary to Apple.
- The PowerOpen environment, which is derived from IBM's AIX implementation of UNIX and also offers Macintosh Application Services (MAS) to provide Mac application compatibility.
- Taligent's future object-oriented operating system, code-named "Pink" and not yet publicly seen, even in beta form.
- IBM's OS/2, which the company has stated will eventually be ported to PowerPC.
- Sun's Solaris version of UNIX, which SunSoft recently announced it plans to port to the PowerPC.

In addition, there are widespread rumors that Motorola is planning a Windows NT port to PowerPC. Motorola executives will say only that they expect PowerPC to run "all significant operating systems." While porting Windows NT to PowerPC is probably the last thing IBM or Apple would like to see, the appeal for Motorola is clear. With Apple still refusing to license its system

Price & Availability

The PowerPC 601 (MPC601) is sampling now, with volume production planned for the third quarter. Pricing is \$280 for the 50-MHz version and \$374 for the 66-MHz part, in quantities of 20,000.

Motorola also introduced a set of software development tools for the PowerPC, currently hosted only on IBM RS/6000 workstations. The software development package (SDP), priced at \$5000, includes C and Fortran compilers, a source-level debugger, and an architecture simulator. The compilers are available separately for \$1500 each, and the simulator is available separately for \$3500. Other workstation platforms will be supported in the near future.

The PowerPC 601 User's Manual (document number MPC601UM/AD) has also been released, marking the first time that complete information on the PowerPC architecture (as implemented in the 601) has been publicly available.

For technical literature, call 800/521-6274. For sales information, call 800/845-MOTO or contact your local Motorola sales office.

software, Windows NT is the only clear path for PowerPC to find high-volume customers outside of Apple.

No PowerOpen licensee could compete effectively with Apple in the PowerPC Mac market, since PowerOpen carries the burden of UNIX's complexity and memory requirements. As long as IBM's plans remain centered around UNIX—or even OS/2—its volumes are likely to be modest. Solaris doesn't have any clear market on PowerPC; makers of PowerPC UNIX systems are likely to use the PowerOpen environment for compatibility with IBM's workstation applications, as well as Macintosh applications, and Solaris application developers aren't likely to port to PowerPC unless a significant Solaris/PowerPC installed base emerges. Finally, Taligent's software, which is not expected to debut until 1995, is too far in the future and has too uncertain a market to serve as the basis of a high-volume strategy.

Windows NT on PowerPC?

Motorola is rumored to have been on the road pitching major PC vendors on building PowerPC-based machines for Windows NT. It would be the third company to make these rounds, following MIPS and DEC. So far, neither MIPS nor DEC has had much visible success in signing up PC players (other than DEC itself, of course) to build RISC machines. Acer is the only major PC maker publicly committed to the MIPS architecture; Olivetti has signed up for both architectures, but it is not clear what that company's plans are. NEC is also expected to make MIPS-based PCs. Notably absent from the MIPS and DEC lists are any major US-based PC makers.

One wild card in Motorola's hand is the IBM PC

Company. So far, the PowerPC efforts appear to be associated primarily with IBM's Austin-based Advanced Workstation division, and it is unclear what the level of interest is from the PC sector. According to press reports, however, IBM has launched a joint-venture effort between the workstation division and the Boca Raton-based PC operation to develop a low-cost system based on PowerPC. It is unclear what operating system such a computer would run; it could be a PowerPC version of OS/2, or the future Workplace OS that IBM has been discussing, or it could be waiting for Taligent. It is even possible that IBM would support Windows NT on the system; while the battle between OS/2 and Windows NT remains intense, IBM has announced plans to support Windows NT on some of its PC servers.

Another possible PC ally for Motorola is Zenith Data Systems. ZDS is owned by Bull, which is, in turn, a member of PowerOpen. Bull is planning a line of workstations and servers based on the PowerPC architecture, and it might encourage its PC subsidiary to follow suit.

While Motorola is late to the game, it is likely to have the advantage of a higher-volume base upon which to build. Apple's volumes alone could put PowerPC in a leading position by 1995, and high-volume production is the key to being able to amortize development costs and continue to invest in new designs. The Somerset design center—staffed with over 300 engineers from IBM, Motorola, and Apple—represents an enormous investment in PowerPC design capability that no other RISC vendor can match. The PowerPC effort is also alone among RISC architectures in its focus on high-volume price points—due, in large part, to Apple's influence.

Other Windows NT Platforms

Of all the possible RISC Windows NT platforms, MIPS appears to be in the strongest position because it is the only RISC architecture that has been supported from the start, which has led to a wide range of development efforts. Several different system-logic chip sets are available, and perhaps most importantly, two low-cost, high-performance processor designs—QED/IDT's Orion and MIPS/NEC's VRX—are nearing completion.

Alpha so far has only a single implementation, the 21064, which is far too expensive for mainstream PCs. No pricing on the forthcoming "Low-Cost Alpha" chip has yet been released, so it is unclear how competitive it will be. With DEC as the only supplier until Mitsubishi comes on line in late '94, however, it is unlikely that pricing will be as competitive as in the MIPS camp. While Digital has clearly bet the company on Alpha, it isn't clear that it will be able to drive Alpha to the low price points needed for high volume. Alpha's most assured success is as a VAX replacement—a market that demands markedly different implementations than Windows NT workstations. Digital will have a tough time matching

the family breadth or the low prices of the MIPS line.

Initially, PowerPC won't match the breadth of the MIPS lineup either. The PowerPC 601 carries a much lower price tag than the year-old R4000, but by the time the 601 is in volume production, the VRX and Orion chips should be rolling out with comparable or lower prices. MIPS also will have the lead at the high end with its R4400 and TFP chips, at least until Motorola comes out with the 604 in late '94—by which time MIPS shouldn't be far behind with its next-generation "T5."

If the MIPS/Windows NT platform does not take off, however, there is some question about how much future investment in a range of processor designs SGI and its semiconductor partners will be able to justify. IBM and Motorola, on the other hand, not only have deeper pockets but also have the relatively assured volumes from Apple to drive their development efforts.

Of course, the biggest competitor for Windows NT systems will be Intel's Pentium. Motorola appears likely to maintain a dramatic price/performance advantage, but this won't mean much unless application software developers support the platform.

Conclusions

The PowerPC 601 is well positioned as a price/performance leader, and barring any blunders on Apple's part, it seems assured of a high-volume role as the heart

of the first RISC Macs. It will also give IBM's workstation division an attractive upgrade for its low-end systems, and it will enable PowerOpen licensees—currently Bull, Harris, Tadpole, and Thomson-CSF—to build IBM-compatible workstations that have the extra benefit of Mac application compatibility. By the end of 1994, the PowerPC line should be much fuller, with the 603 and 604 in production and the high-end 620 sampling.

PowerPC's role in the broader PC market appears to depend on its possible role as a Windows NT platform. From a price/performance point of view, it should be a potent competitor, but it is far behind MIPS and even Alpha in drumming up support among chip-set vendors, system makers, and software developers. Its role as the heart of the RISC Mac could provide some leverage; Mac software developers, armed with PowerPC expertise, systems, and software tools, might find a PowerPC-based Windows NT platform an attractive alternative.

Ultimately, the key to success for any RISC Windows NT platform will be the support of application software developers. These developers, in turn, will look for credible makers of PCs that are building systems based on the architecture as a sign that the architecture has a chance to build a significant base. The critical factor for Motorola, as well as MIPS and DEC, then, is to convince the leading PC makers to build a RISC-based PC—something that none have yet been willing to do. ♦