MICROPROCESSOR REPORT

THE INSIDERS' GUIDE TO MICROPROCESSOR HARDWARE

VOLUME 7 NUMBER 16 DECEMBER 6, 1993

PowerPC Gains NT and PCI Support

IBM Deploys Reference Platform to Stimulate Multivendor Market

by Linley Gwennap

Attempting no less than to duplicate its success with the original IBM PC, the world's largest computer company has announced what it hopes will be the standard platform for personal computing into the next century. IBM, along with Motorola, unveiled a specification for PowerPC systems running Big Blue's AIX and Workplace OS, Sun's Solaris, Taligent OS, and perhaps most importantly, Microsoft Windows NT. IBM expects all of these operating system to ship by the second half of next year.

At Comdex, Apple CEO Michael Spindler foreshadowed eventual availability of System 7 on third-party PowerPC platforms. Even without Apple's OS, the recent announcements could boost the volume of PowerPC processors far beyond other RISCs, positioning it as the primary alternative to the x86. If Apple comes through, volumes could go even higher, particularly in the short term. Thus, these announcements are critical to the future success of the PowerPC architecture.

The PowerPC Reference Platform (Prep) defines a set of requirements for compliant systems. Systems that adhere to the specification will be able to run shrink-wrapped operating systems and applications for the PowerPC. By creating a specification instead of a single reference system, Prep allows system makers much more flexibility that the PC/AT, for example, which gave PC-compatible vendors few options other than to copy the IBM system directly. Prep includes a set of software interfaces to hide differences in the hardware designs.

Both IBM and Motorola stress that the new platform will be completely open. The Prep specification itself will be freely distributed and contains no royalty-bearing intellectual property. IBM says that there will be no per-system royalty for use of its design kits. System makers may have to pay for some patent rights or firmware licensing when implementing the specification, but the companies expect these to be comparable to the royalties required on current x86-based PCs.

IBM Microelectronics also announced a PCI system-logic chip set for PowerPC processors. Although Prep does not specifically require PCI, the example designs all use PCI as the local bus, since VL-Bus has no advantages for a non-x86 system. IBM's chip set is similar to x86 PCI chip sets and is expected to begin shipping next April for $70 in high volumes.

The Do-Anything Desktop

Prep attempts to be the Swiss Army knife of systems. If you want UNIX, you can choose between AIX and Solaris, two of the more popular flavors of the splintered standard. If you want object-oriented not-quite-there-ware, talk to Taligent, the IBM/Apple spinoff (see MPR 10/16/91, p. 1). If you want a PC-style operating system, there's Windows NT or Workplace OS, which will be a portable version of OS/2 that, according to IBM, will require less system memory than NT.

Windows NT promises to bring the mainstream of PC computing to PowerPC. That promise, however, may take years to fulfill, as NT today is trapped at the high end of the market, good mainly for servers and for desktop power users. Chicago (Windows 4.0), which will not run on PowerPC, will satisfy the bulk of the PC market in 1994–95.

Over time, however, CPU performance and memory capacities will increase, paving the way for NT (or its successor, Cairo) to move into the volume sector of the market. With Prep and patience, IBM and Motorola hope to capture some of that volume.

For system vendors, the allure of Prep is twofold. First, vendors don't have to bet on any single OS; by building Prep hardware, a vendor can succeed if any of these operating systems do well. The second attraction is the opportunity to get out from under the thumb of Intel and take advantage of the better price/performance of PowerPC processors.

Like most knives, however, the Swiss Army strategy cuts both ways. Systems based on the x86 already run Windows, NT, OS/2, several versions of UNIX (in-

cluding SCO and Solaris), object-oriented who-cares-ware from Next, and a variety of other operating systems. So while the PowerPC is more flexible than any of the competing RISC architectures, it still offers no real advantage over the x86 in this regard—unless Apple follows through with licensing the Macintosh OS.

Also, system vendors who would like an alternative to Intel could get hurt if the company chooses to squeeze supplies of its x86 processors, particularly the single-sourced Pentium. Sales of Prep systems are likely to be small, at least initially, and full-line PC vendors may not be willing to jeopardize their main revenue stream for PowerPC. Niche vendors, particularly in the notebook area, who can get their x86 chips from alternate suppliers may be more willing to take on the RISC platform.

IBM Forms New Division

The first company to sign up for Prep, not surprisingly, is IBM, which played a major role in the development of the specification. Not only is Big Blue the biggest backer of PowerPC, but it has its own internal supply of x86 chips should Intel get testy. The company has created a new business unit, Power Personal Systems (PPS), to design and market personal computers based on PowerPC. The new entity is managed as a separate business from the IBM PC Company and the Advanced Workstation Systems Division, although many of the individuals in PPS came from these two established organizations.

Certainly, having a first-tier PC vendor endorse the new PowerPC platform is a major accomplishment, one that has eluded MIPS, Alpha, and other PC aspirants. The IBM PC Company itself, however, remains focused solely on its x86 product line. PPS will be able to take advantage of IBM's deep pockets and, perhaps more importantly, the distribution channels of the IBM PC Company.

PPS systems are expected to debut in middle of next year running Windows NT, AIX, and possibly OS/2 (via Workplace OS) and Solaris. They will initially be at the high end of the PC market, which is appropriate given the OS choices available. Early adopters will probably be low-end workstation customers and NT power users. As NT enters the volume market in the middle of the decade, PPS system prices are expected to fall. The new unit also hopes to take advantage of the performance of PowerPC to offer more advanced user interfaces such as voice recognition and realistic video agents.

IBM Microelectronics, formerly known as the Technology Products Group, also plays an important role for PowerPC. While PPS designs and markets systems, the Microelectronics unit will make the key components available on the open market, enabling other vendors to build similar systems. Unlike Sun's equivalent unit, SPARC Technology Business, IBM is giving potential customers plenty of advance notice; the PCI chip-set announcement comes six months before the expected availability of IBM systems.

To assist the development of third-party PowerPC systems, IBM Microelectronics announced plans for two motherboards implementing the Prep specification. The unit says that it will market these boards next year, and will also make design kits available for those vendors that wish to build the boards themselves. These kits will include all specifications, Gerber tapes, bill of materials, and other information needed to put the boards into production. No pricing is available for any of these products, but the company expects that the design kits will be available at a fairly low cost, probably under $5,000.

Prep Specification Allows Flexibility

The new specification gives implementors a variety of options in creating systems. Unlike the original PC/AT standard, which requires register-level compatibility and fixed addresses, Prep allows much more flexibility for the system designer. In theory, this will give system vendors the ability to create differentiated systems and add value, an option that is much harder to find in the x86-based PC market.

Prep assumes the existence of a machine abstraction layer, something like BIOS code but more comprehensive and kept on disk rather than in ROM to simplify updates. This follows the lines of the Hardware Abstraction Layer (HAL) in Windows NT, but other Prep operating systems will also implement a similar concept. This allows specific details of the hardware implementation to be taken into account by low-level software; the OS and applications need not worry about such issues. Similarly, device-driver standards hide the specifics of the peripheral interfaces from the software.

Although Prep is not bus-specific, all the initial implementations use PCI as the local bus. Processors with the performance of the PowerPC family require a high-speed local bus; in the PC world, the choices are PCI or VL-Bus. The latter is tightly tied to the 486 local bus, so for PowerPC systems, PCI is the obvious choice, particularly considering the wider range of peripheral chips and bus bridges currently available or under development.

By starting afresh in 1993, the designers of Prep made assumptions not possible for the PC/AT standard. Typical Prep systems will have a mouse, audio capability, a CD-ROM, and an accelerated $1024 \times 768 \times 16$ display, along with standard serial and parallel ports. At least 16M of memory and a 200M hard drive are strongly recommended. The specification allows for upgrade processors and multiple processors.

Two Missing Pieces

Many of the recent announcements, in particular the Windows NT port, have been anticipated for some time *(see **070602.PDF**)*. As often happens, the actual an-

nouncements were not quite as good as the early speculation.

In particular, Motorola presumably had hoped to announce one or more system vendors (in addition to IBM) that would adopt the Prep specification, but this did not come to pass. Motorola has had (and continues to have) high-level discussions with virtually all the top-tier PC vendors, and many others as well. Sources indicate that Motorola has unannounced deals with at least one major PC maker and hopes that additional vendors will sign on now that IBM's willingness to open the specification has been confirmed.

A second rumor that has been long-lived is the possibility of Apple licensing its Macintosh operating system (System 7) on the Prep platform. Apple has made no announcements but CEO Spindler said the company is "evaluating" such a move. Apple did help develop the Prep specification. Initial PowerPC Macintoshes will not be Prep-compliant, as the design of these systems is too far along to make changes, but future Apple systems may follow the specification. The biggest problem would be inserting the HAL-like layer required to insulate the OS from the Prep hardware; Mac OS currently interfaces directly to the hardware.

Although Apple considers the Macintosh software its crown jewels, over the years it has become increasingly apparent that the company made a major mistake in locking up its jewels. Although Microsoft Windows, particularly in its early versions, was clearly inferior, it has become the dominant PC operating system through its broad availability, while Mac OS has been stuck at 10–15% of the market. Even now, it is not too late to open the Macintosh platform before it becomes increasingly irrelevant to the desktop market.

Apple is planning an x86 version of Mac OS, which is being developed with Novell *(see **0707ED.PDF**)*. It is not clear which vendors will build systems for this OS or where the applications will come from. If Apple were to license Mac OS on PowerPC, on the other hand, system vendors could tap into the same software base that will be used for Apple's own PowerPC systems.

By opening Mac OS, Apple would give Prep an additional edge: a high-volume PC operating system that is not available on the x86. With any reasonable licensing fees, it seems that there would be some vendors willing to build Macintosh-compatible systems and take advantage of the relative lack of competitors in that market. As an additional incentive, the same hardware would also run Windows NT and the other Prep operating systems.

Sources indicate that Apple is currently shopping Mac OS to a variety of system vendors using this pitch. One company rumored to be paying attention is Acer. The Taiwanese PC maker already has a manufacturing relationship with Apple, and may want to build and market PowerPC Macs. Acer also sells MIPS-based PCs and thus has experience with RISC designs. It appears that neither Acer nor Apple, however, has committed to this strategy.

It makes little sense for Apple to announce a licensing program without any customer commitments; Motorola, at least, had IBM committed to NT-on-PowerPC. Furthermore, the companies felt obligated to make the NT announcement by Comdex, a less-interesting deadline to Apple. Thus, we will have to wait to see if Apple follows through with a licensing program. In the near term, this could be PowerPC's biggest volume opportunity outside of Apple itself.

Price and Availability

The 82650 chip set, including the PowerPC-to-PCI system logic and the 82374 PCI-to-ISA bridge, is priced at $73 in annual quantities of 50,000 or $90 in quantities of 10,000 units. The chip set is currently sampling with volume availability planned in April. For more information on this chip set, the Prep specification, or PowerPC design kits, contact IBM Microelectronics at 800.POWERPC or 802.769.6899.

Not Just Another Pretty ACE

The recent announcements are reminiscent of the ARC platform that was announced a few years ago, but this is not just ACE redone. The numerous members of ACE spanned the gamut from PC makers to vendors of multiprocessor fault-tolerant servers. The conflicting marketing needs of these varied companies prevented the coalition from making progress. Prep, in contrast, is mainly focused on personal systems. Eventually, with the PowerPC 620, large servers could be built under the specification, but there is no need for that today; the PowerOpen coalition covers the server market.

ACE members also struggled with the endian issue. Although the consortium officially called for little-endian systems compatible with PCs and Windows NT, a number of members had large installed bases of big-endian systems and never felt comfortable with the switch.

To solve this problem, Prep requires systems to run in a biendian mode. Since PowerPC processors are all biendian, this simply requires external "lane switching" logic for byte loads and stores, allowing any Prep system to run little- or big-endian software. (AIX and Mac OS are big-endian; NT and Workplace OS are little-endian; Solaris goes both ways.) Motorola and IBM claim that this adds little cost over a single-endian platform.

For ACE, the presence of Compaq provided legitimacy in the PC market, and Compaq's later withdrawal put ACE in the hole. Today, ARC-compliant systems from Acer and NEC are ACE's primary legacy. For Prep, IBM is the key PC player and is unlikely to "pull a Com-

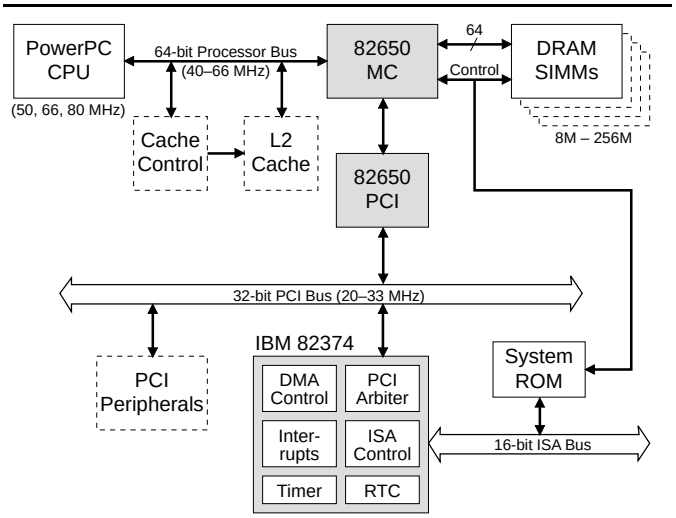

Figure 1. IBM's 82650 chip set connects a PowerPC processor to cache, main memory, PCI, and ISA with standard system logic.

paq" on its partners.

New Chip Set Bolsters PCI

The new chip set from IBM Microelectronics, the 82650, supports PowerPC 60x processors (the 601, 603, and 604 all use a similar bus interface). As shown in Figure 1, it provides memory control, system ROM control, a PCI interface, some standard system logic, and a bridge to ISA. A secondary cache is optional; if included, a separate ASIC is required to control the cache.

The '650 is the first in a family of PowerPC chip sets from IBM and was designed to reach the market as soon as possible. Thus, it does not have a full set of features compared to PCI system-logic chip sets for Pentium and Alpha processors. The lack of support for an external cache is one such area. IBM plans to have additional chip sets that solve these problems on the market by the middle of next year. Motorola and other vendors are also planning to market PowerPC system-logic chip sets.

In the meantime, the '650 will support PowerPC chips with processor bus speeds up to 66 MHz; the recently announced 80-MHz versions of the 601 and 603 *(see **071402.PDF**)* can be used in clock-doubled mode with a 40-MHz processor bus. Since this would set the PCI speed at 20 MHz, however, this configuration is not likely to be used with the '650 chip set.

The secondary cache, if provided, must be controlled by custom logic. IBM claims that this logic could be implemented in a $5 ASIC. At 66 MHz, the cache would require 11-ns data SRAMs and 10-ns parts for tags. The size of the cache would be limited only by the design of the cache-control ASIC.

The memory controller included in the '650 supports main memory sizes of 8M to 256M using standard SIMMs. To reduce time to market, the chip set supports only parity protection for main memory; future chip sets will include ECC as well. Only a few timing modes are allowed; with 70-ns page-mode DRAMs, data is returned in a 6-4-4-4 pattern at 66 MHz. The chip set can interface to 5-V or 3.3-V memory chips.

The bus interface is compliant with PCI version 2.0. The 32-bit PCI bus runs at one-half the processor bus frequency (33 MHz maximum) and can operate at either 5 V or 3.3 V. DMA transactions cannot occur in parallel with CPU-to-cache accesses; this is another feature that will be included in future chip sets.

The '650 can be used with IBM's 82374 PCI-ISA bridge chip. This chip is fairly similar to Intel's 82378 (which is also compatible with the '650) but it allows for six ISA slots, two more than the Intel chip, and it includes a real-time clock not found in the Intel version.

The '650 is also compatible with Intel's 82374/5 PCI-EISA bridge chip set. IBM has indicated plans for a PCI-PCMCIA bridge that would be useful for 603-based notebook systems but did not state availability for such a chip. In the interim, standard ISA-based PCMCIA controllers can be used. Ultimately, the company may deliver a PCI-MCA bridge as well.

The '650 chip set is expected to begin shipping next spring. Future chip sets will support additional features not found in the initial 82650 product. Along with those previously noted, IBM plans to deliver a chip set that handles the 32-bit-bus mode supported by the PowerPC 603. By reducing the pin count for the bus, this product could be more integrated than the current one, resulting in a lower-cost chip set for portable and low-end systems.

PowerPC Outdoes Pentium

Table 1 compares the features of the 82650 chip set with Intel's PCIset for Pentium and Digital's PCI chip set for the 21064 *(see **070904.PDF**)*. All three do an adequate job of supplying system logic for their designated CPU, and all have a similar price. The biggest difference is that the IBM chip set is missing features, such as secondary cache control and ECC, that the other chip sets include. The Alpha chip set supports larger caches and more main memory than the others, allowing it to be used in high-performance servers.

The most significant distinction among these chip sets is the price and performance of the CPUs that they work with. Using caches, memory, and peripherals of similar cost, the PowerPC and Alpha configurations deliver 20–40% better performance than Pentium, but the price of the two RISC chips is about $400 less than that of a Pentium. Note that the Alpha configuration shown is the low end of the Digital line; Alpha processors are capable of much better performance than current PowerPC or Intel chips.

The new chip set allows PowerPC to take advantage of standard SRAMs, SIMMs, and PCI peripherals, keep-

ing costs comparable to high-end x86-based PCs. Several leading graphics vendors such as Cirrus, S3, and Weitek have announced that they will support PowerPC drivers for their PCI graphics accelerators; NCR and National will support PowerPC for PCI networking chips. With existing bridges from PCI to ISA and EISA, PowerPC can access a wide range of standard PC peripherals.

Digital has chosen the same strategy as IBM and is also putting its weight behind PCI. The Alpha 21066 even integrates system logic and a PCI controller onto the processor itself *(see **071201.PDF**)*. Taking no chances on third-party support, Digital is developing its own line of PCI peripherals, starting with the recently announced 21040 Ethernet adapter.

A New PC Standard?

By using the same system components as x86 PC makers, potential Prep vendors could theoretically deliver better price/performance than Pentium systems, based on the superior capabilities of the PowerPC processors. There are many obstacles in the way, however, such as the lower volumes of the Prep systems, lack of sales channels, and the lack of major vendors, other than IBM, committed to the new platform. The biggest problem is the lack of application software for Prep.

Both Motorola and IBM view this as a long-term opportunity to unseat the x86. Sales of Prep systems will be low until a high-volume operating system is available on PowerPC. If NT ultimately fulfills its expectations, the superior price/performance of the PowerPC architecture could give it a leg up on x86-based systems. This will probably not occur until 1996, at best.

If Apple is willing to license Mac OS on Prep, it could jumpstart the market for these systems. A few other vendors building these platforms would go a long way toward establishing its viability. Multiple vendors would increase the volume of Prep hardware and give the platform increasing momentum as Windows NT approaches the mainstream.

Without Mac OS, however, there appears to be little short-term incentive for major PC vendors to build Prep systems, since the incremental sales will be small compared to x86 PCs. Initially, startup companies without x86 product lines may be more attracted to the new platform due to its opportunities for higher margins and differentiation. Most PC vendors will probably let someone else (like IBM) demonstrate the viability of Prep platforms.

Processor	PPC 601	Pentium	21064
Chip Set	IBM 82650	PCIset	Digital
Max CPU Clock	80 MHz	66 MHz	200 MHz
Cache Width	64 bits	64 bits	128 bits
Min Cache	0	0	128K
Max Cache	n/a	512K	16M
Synch SRAM?	Yes	Yes	No
SRAM Speed	11 ns	15 ns	15 ns
DRAM Width	64 bits	64 bits	64 bits
Min DRAM	8M	2M	8M
Max DRAM	256M	192M	4G
PCI Slots	2	2	2
ISA Slots	6	4	4
DMA Control?	Yes	Yes	Yes
Interrupts?	Yes	Yes	Yes
Timer?	Yes	Yes	Yes
Real-Time Clock?	Yes	No	No
Chip Set Price (1K)	$90	$84	$75 (est)
CPU Price (1K)	$450	$898	$505*
Est. SPECint92	68	57	80*

Table 1. PCI chip sets from all three vendors offer many of the same features at similar prices; the biggest difference is the price and performance of the processors that they support. (SPECint92 using 512K 15-ns SRAM and 70-ns DRAM; *for 150-MHz 21064 CPU.)

If IBM successfully establishes a market for these systems, the PC industry will undoubtably follow, herd-like, in its path, and there will be plenty of time for these companies to build and deploy compatible systems. In the meantime, the watchwords for most companies will be wait and see.

The Prep platform needs another major system vendor to commit; one small division of IBM may not be enough to propel it to success. PowerPC's price/performance advantage will not spur the volume of IBM's Prep systems without a high-volume OS. IBM Microelectronics is off to a good start in supplying the chip sets and design kits needed to spur a clone market; the table is set, but we're waiting for the guests to arrive. ♦

*Our next issue will contain a detailed description of the Prep specification (see **071704.PDF**).*

