PowerPC Alliance

By Charles R. Moore and Robert L. Mansfield

The PowerPC alliance represents a significant commitment by IBM and its partners to make the PowerPC Architecture and the PowerPC microprocessors successful. The architecture addresses the diverse computing requirements of the future and will enable development of a wide range of compatible systems.

In September 1991, IBM, Apple, and Motorola announced a broad alliance to develop some emerging technologies. The alliance formed around five principle initiatives:

- **Object-oriented technology**. Apple and IBM agreed to form Taligent™, a wholly owned subsidiary, to develop and license an operating system based on object-oriented design principles.
- **Multimedia technology**. Apple and IBM agreed to form Kaleida™, a joint venture, to create and license multimedia technologies.
- **Interconnectivity and networking**. IBM and Apple agreed to develop hardware and software solutions that allowed their systems to interact more effectively.
- **Open systems environment**. Apple, IBM, and Motorola agreed to define the PowerOpen™ environment. PowerOpen, which can run both AIX and Macintosh® applications, will be licensed to other vendors.
- **Microprocessor technology**. IBM and Motorola agreed to develop a broad family of microprocessors based on the PowerPC Architecture, a component of IBM's POWER Architecture™.

The IBM/Apple/Motorola alliance allows the partners to share the expense and risk of developing and marketing new technology. It also clearly demonstrates their collective commitment to the open systems philosophy. The alliance benefits from the strengths that each partner brings to the venture:

- Apple brings an innovative, consumer-oriented system design style, the industry's best personal computer software technology, and a sophisticated user interface.
- Motorola, one of the leading semiconductor manufacturers, has a worldwide distribution network. Motorola offers outstanding microprocessor design skills, especially in low-cost and compact design styles.
- IBM brings outstanding microprocessor design skills to the alliance, with emphasis on high performance and proven design methods. In addition, IBM brings years of experience and research in computer architecture, multimedia, and object-oriented technology.

The alliance is committed to the PowerPC Architecture and to the PowerPC family of microprocessors. The companies have agreed on goals that bring the architecture to the forefront of the computing world and enable a broad range of PowerPC-based systems.

PowerPC Architecture

There were several goals for the PowerPC Architecture. First, it was important that the architecture maintain an Application Binary Interface (ABI) compatible with IBM's POWER Architecture. This allows PowerPC-based machines to leverage the application base that exists for IBM's RISC System/6000 machines. To do this, the alliance selected the user-level instruction set

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and programming model of POWER as a starting point for the PowerPC Architecture. Although the final PowerPC Architecture added some instructions and deleted others, the compilers and operating systems can manage these changes effectively. (See "XL Compiler Support for New RISC System/6000 Architectures" in this issue.)

The second goal was to simplify the architecture and ease unnecessary implementation requirements. This flexibility allows hardware designers to make optimizations that are appropriate for specific target markets. In addition, the simplifications allow for smaller chips, faster cycle times, and more aggressive superscalar implementations.

A third objective of the PowerPC Architecture was to provide support for a wide range of uniprocessor and multiprocessor system configurations. Achieving this objective required recognizing key components of the storage hierarchy and defining a storage control architecture for effective management of these components. The architecture also allows storage references to follow either a big-endian or a little-endian byte-ordering convention.

Finally, the PowerPC Architecture definition includes a set of 64-bit extensions that allow upward compatibility for 32-bit applications. The architecture defines the 64-bit instruction operation as a logical extension to the 32-bit execution model. Extensions to the memory management architecture allow 64-bit addresses to be translated. For flexibility, each implementation can comply with either the base 32-bit PowerPC Architecture or the extended 64-bit architecture.

PowerPC Microprocessors

Beyond just a commitment to the PowerPC Architecture, the alliance also plans to develop a family of single-chip PowerPC microprocessors. The alliance expects the initial family of microprocessors to provide superior solutions for system designers across a wide range of system designs. Microprocessors must be general purpose with versatile interfaces. Although some microprocessors may require trade-offs in performance, price, and adherence to standards for particular market segments, they must all exploit the advantages of the PowerPC Architecture to achieve high performance.

To develop these devices, IBM and Motorola jointly formed a PowerPC design center called Somerset in Austin, Texas. Approximately 300 experienced microprocessor designers staff this center, managed jointly by both companies. The center has established a design methodology that enables the team to achieve high-quality, aggressive designs on relatively short development cycles. The methodology consists of blending tools that enhance designer productivity with tools that allow for full custom design and analysis. The tool set allows either IBM or Motorola manufacturing facilities to fabricate the designs using a common half-micron CMOS process.

The alliance partners agreed to an initial microprocessor roadmap that specifies four independent design points. Each of these points is expected to bring industry leadership solutions to its segment of the computing market. The initial four design points are as follows:

- The PowerPC 601™ microprocessor, the first member of the family, is the product responsible for bringing the PowerPC to the market as soon as possible. It targets customers who adopted the PowerPC at the beginning. It is ideal for use in desktop computers, portable systems, and low-end multiprocessor systems. The design implements the 32-bit PowerPC Architecture and achieves competitive performance at a low cost. Processor chips have been available since early 1993, and the first 601-based systems have been available since late 1993.
- The PowerPC 603 microprocessor addresses the low-end and low-cost range of the 32-bit PowerPC family. IBM has two primary goals for this processor: it must fit onto a very small chip and it must dissipate very little power. The intended market is low-end desktop and portable systems. The processor will offer competitive performance and will be available in early 1994.
- The PowerPC 604 microprocessor is designed for mainstream computing environments including personal computers, midrange workstations, and multiprocessor systems. The chip is a 32-bit implementation of the PowerPC Architecture and uses advanced superscalar design to achieve high performance. It will be available in mid-1994.
- PowerPC 620 microprocessor delivers the maximum performance achievable with the currently available half-micron CMOS process technology. This superscalar design implements the full 64-bit PowerPC Architecture and includes an embedded L2 cache controller that interfaces to standard Static Random Access

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Memory (SRAM) chips. The design targets high-end desktop computers, work-group servers, and transaction processing-based systems. The chip will be available in the second half of 1994.

IBM plans to use these four microprocessors in future products. Both IBM and Motorola will also independently market and sell the chips for use by other system developers. Extending the PowerPC family to the open market is an important and strategic part of the alliance's plan to make the PowerPC successful. Making the chips available will entice more independent software developers to write applications for PowerPC-based systems.

PowerPC-Based Systems

The PowerPC microprocessors will broadly affect IBM's product line. The cost effectiveness of these microprocessors, combined with high performance and binary compatibility with POWER, opens many new opportunities to take advantage of the PowerPC technology. During the next several years, it is likely that IBM will offer PowerPC-based systems ranging from palmtop personal organizers to massively parallel teraFLOP machines. Several IBM product lines have already made design commitments to the PowerPC; other important statements of direction have been publicized.

The four microprocessor designs described here represent only the beginning in PowerPC processor development.

IBM's RISC System/6000 Division will offer compatible systems based on both the POWER and PowerPC Architectures. This approach will allow mainstream workstations to leverage the cost advantages of the PowerPC, while simultaneously preserving market differentiation by offering even greater performance for existing investments in POWER-based systems.

A separate alliance between IBM and Group Bull® has committed to developing symmetric multiprocessor-based systems using PowerPC microprocessors. The approach of this alliance is to leverage the high performance and low cost of several processors, thereby offering superior solutions in the transaction processing and server environments.

To underscore its commitment to the PowerPC Architecture, IBM has created the Power Personal Systems Division. Its mission is to develop a line of personal computers that will use the PowerPC microprocessors. These new systems will offer an alternative to traditional personal computers and will be designed to comply with the Open Systems philosophy. These systems will be able to support a wide range of industry-standard operating systems.

Future Directions

The four microprocessor designs described here represent only the beginning in PowerPC processor development. As technology continues to advance, performance will improve, integration will become simpler, power consumption will decrease, and costs will fall. IBM and Motorola are committed to incorporating technology advancements into their processor development efforts and to extend the product line to accommodate a greater range of computing requirements.

IBM expects the existing design points to become usable as "cores" for more fully integrated and optimized solutions for particular target applications or markets. These cores will also be made available to customers who develop their own application-specific VLSI solutions.

Finally, some aspects of the PowerPC Architecture will be incorporated into other market segments. For example, in a separate effort, IBM is developing a line of embedded controllers based on a subset of the PowerPC Architecture. These controllers will be suitable in less demanding environments than the general-purpose computing environment, yet still produce high performance at a low cost.

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