Power.org Gains Freescale, Advances Ecosystem

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Processor Architectures as Organisms

Microprocessor architectures are like living organisms. Typically an architectural species originates to address a single application market. As that market's environment changes, the species either adapts or becomes extinct. The most successful ones adapt further and spread into additional areas, assuring the survival of the species despite change in one area's environment. Success of the species also depends on the robustness of its ecosystem. If the ecosystem withers, so too will the species. Conversely, the species can permute to a point at which it overloads the ecosystem and thus compromises its own existence. Unlike a living organism, however, an architectural species and its ecosystem are the product of human endeavors. The species and its ecosystem have the option of choosing to adapt not just in reaction to change, but also in anticipation of change.

Power Architecture is a species that has successfully adapted to multiple application markets. It maintains its strength in its original market, computing, and is also strong in multiple embedded applications. This diversity positions it for further adaptation to address emerging application markets, assuring its endurance for years to come.

Further, the ecosystem that includes Power is making strides toward defining its destiny by coming together as the Power.org community. Freescale Semiconductor is an important addition to the organization and rejoins IBM in collaborating on the future direction of Power Architecture. With Freescale's participation in Power.org, the Power Architecture ecosystem is better positioned to not just endure, but to prevail—to evolve, to build on its strength in key application markets, and to proliferate into new markets.

Power Architecture Applications

Power Architecture originated to address computing applications. IBM implemented it first implemented in 1990 as IBM's POWER processor for midrange computers. Almost immediately it began the process of adaptation that continues today. In 1991 IBM joined Motorola, Inc.'s Semiconductor Product Sector (the corporate predecessor to Freescale Semiconductor, Inc.) and Apple Computer, Inc. to adapt it for use in Apple's personal computers. This adaptation, known as the PowerPC® instruction set architecture, succeeded Motorola's 68000 architecture and set the stage for Power Architecture to adapt further and spread into embedded applications. Although the personal computing environment is no longer favorable to Power Architecture technology, the architecture maintains its strength in the server market, and it dominates key embedded application markets.

High-Performance Computing and Enterprise Servers

While Power Architecture is used in a variety of applications, it is probably most often associated with computing. The fastest computers use Power Architecture processors. Half of the 20 fastest supercomputers are built on Power processors (source: Top500.org, November 2005). The three fastest are IBM Power machines. The fastest, BlueGene/L, has more than 130,000 PowerPC processors and is as fast as the next five supercomputers combined. A smaller BlueGene occupies the second position. The third position is held by ASC Purple, which uses far fewer—“only” 10,240—and far more powerful POWER5 microprocessors to deliver a quarter of the performance of BlueGene/L with a tenth the number of processors.

Supercomputers are specialized systems for unusual applications, such as atomic energy and genetic research. In contrast, enterprises need off-the-shelf, high-performance servers for processing database transactions. Here, too, Power Architecture dominates the benchmarks, holding six of the top ten spots on the TPC-C ranking (source: TPC.org, January 2006), including the top two positions.

Servers are the main driver of Power Architecture technology for IBM. Since releasing the first POWER microprocessor in 1990, IBM has extended the architecture from 32 bits to 64 bits, released dual-core versions, increased I/O bandwidth, and added support for simultaneous multithreading. Such enhancements have delivered the real-world performance advantages and scalability that have led to Power becoming one of the most widely used server architectures. Investing in Power Architecture for servers enables IBM to differentiate itself from competitors reliant on commodity server technology, enabling the company to address lucrative high-end segment of the server market. Power Architecture, therefore, is essential to IBM’s successful enterprise systems business.

Communications Systems

Power Architecture is also well known among designers of networking and communications systems. Every major supplier of these systems uses Power Architecture in at least one product family. For example, Power microprocessors are used in the fastest routers from Cisco, telephone switches from Nortel, and 3G cellular base stations from Ericsson. Its widespread adoption has led to Power Architecture becoming the most common architecture for standalone microprocessors used in communications systems, with sales exceeding that of all other architectures combined.

All three suppliers of Power Architecture processors—Freescale, AMCC and IBM—serve the communications systems market. Freescale pioneered the use of Power in this market and remains the leading supplier, largely because of the success of its PowerQUICC™ communications processors. Each of the dozens of different PowerQUICC chips combine a Power Architecture core with a different set of communications-related features, such as a RISC-based Communications Processor Module (CPM), Ethernet interfaces, encryption engines, telephony interfaces, and controllers for ATM and other protocols. In mid-2005, Freescale announced a dramatic overhaul of the CPM: QUICC Engine™ technology. This new technology, paired with a Power Architecture microprocessor, is engineered to deliver several times the networking performance of earlier PowerQUICC processors.

Paralleling Freescale’s success selling Power processors with integrated communications peripherals, IBM developed the 4xx series of PowerPC chips. AMCC acquired this line from IBM in 2004 as IBM sought to diversify the companies supplying processors based on Power Architecture. In addition to serving the communications market, AMCC has begun to use the 4xx processor for RAID accelerators for servers. IBM continues to market its discrete microprocessors for communications use.

Console Game Machines

In 2004, Sony, Microsoft, and Nintendo shipped a combined total of 23 million console game machines (source: Gartner, 2005). By the end of 2006, all three will have begun shipping their next-generation designs, all using the Power Architecture, and game console shipments are projected to climb to 37 million in 2007 (source: Gartner, 2005). The architecture was first used in a game console when IBM captured the Nintendo GameCube design, which began shipping in 2001, displacing the incumbent MIPS architecture. Power Architecture displaced MIPS again when Sony chose IBM and the innovative Cell processor for the next-generation PlayStation. IBM displaced Intel in the Microsoft XBox 360 console with a custom triple-core 3.2GHz Power Architecture CPU. No matter which next-generation console is the most popular, Power Architecture will be the number one microprocessor for game consoles for the rest of this decade.

Automotive

About half of all 2006 car models have a Power-based Freescale microcontroller under the hood, and the top five automakers all use Freescale's Power Architecture microcontrollers. Freescale is the leading supplier of microcontrollers for automotive use. Most of these are 8-bit or 16-bit devices performing simple functions. Modern engine-management systems and electronic transmissions, however, are not simple functions. They require megabytes of software implementing complex algorithms that process dozens of inputs to control emissions and optimize engine power. Freescale's microcontrollers based on PowerPC cores have the processing capability, on-chip memory, analog capabilities, powerful timing systems, and other features required to handle modern automobiles' complex control and diagnostic systems. As braking, suspension, and safety systems become more sophisticated, they too are beginning to use these microcontrollers, continuing the trend of increasing processing capabilities within cars.

Power.org: Defining Power Architecture's Destiny

Strong in multiple application markets, Power Architecture and its ecosystem could continue to *survive* by evolving ad hoc and adapting to environmental change. But IBM realized that for Power to *endure* the architecture needed to adapt and expand into application markets beyond that which it and its existing partners could serve. For Power to *prevail*, Power ecosystem partners need to act positively and cooperatively in advance of environmental change. IBM therefore created Power.org.

Power.org is a forum for members of the Power Architecture community to collaborate on proliferating the architecture. Important aspects of collaboration include promoting the architecture, reducing the costs of developing software and systems based on it, and adapting it and its ecosystem to new applications. Further, Power.org opens the architecture to new ecosystem partners.

Power.org's initial goal was to make itself known to the Power Architecture ecosystem and attract members. With more than 40 dues-paying companies, including the ten founding members, Power.org has found widespread corporate interest. Freescale's joining is significant because it is the leading supplier of Power Architecture processors to the multifaceted embedded systems market. The next goal for Power.org is to translate this high-level, general interest into enthusiasm and meaningful action by member companies and their individual employees. Having attracted thousands of individual developers, Power.org is off to an auspicious start in developing grass-roots enthusiasm.

With the ecosystem organized, Power.org is turning its efforts toward the cooperative development of the architecture to optimize the process of its adaptation and proliferation into new application areas. As a consortium, Power.org provides explicit mechanisms for the Power community to set goals and collaborate on achieving them, increasing the likelihood that Power.org will meet its objectives of standardization, innovation, and promotion. One way that Power.org facilitates collaboration is through technical subcommittees (TSC). Power.org defines through its bylaws processes for creating a TSC in which members contribute intellectual property on reasonable and non-discriminatory or royalty-free terms. Defining the processes well enables members to create a subcommittee and begin meaningful work without getting bogged down in the formation stage.

An important cooperative development effort is taking place in the Power Architecture Advisory Council (PAAC) TSC. PAAC will manage the evolution of the instruction-set architecture. With its nucleus of IBM and Freescale, it builds on the history of collaboration that led to genesis of the PowerPC architecture and its subsequent "Book E" extensions. PAAC will coordinate the integration of new architectural features, maximizing compatibility among the various suppliers of Power Architecture processor.

Unlike previous collaborations, which involved only two or three companies and focused narrowly on processor design, Power.org is far more open. Its primary goal is to nurture the whole Power ecosystem. Part of this nurturing will come from the sharing of ideas among parties with diverse experiences. For example, the designer of a secure network gateway might observe that performance enhancements, such as multithreading, that IBM implemented to maximize server throughput could accelerate security processing. The designer could then initiate a process whereby the feature is standardized for use in embedded systems.

Another goal of Power.org is to reduce the cost of developing Power Architecture systems and software by reducing hardware differences that do not provide value-added differentiation. For example, an Ethernet switch and a server may both use code-compatible processors, but the systems may initialize their peripherals differently. Thus, while both systems run the Linux® kernel, each needs its own code branch—raising the effort needed to support the kernel on Power. The Power Architecture Platform Reference TSC, however, is working on standardizing system-level functions to reduce the non-value added differences among Power-based systems and facilitate use of prepackaged software.

In addition to promoting Power Architecture in the sense of increasing awareness, Power.org seeks to promote the architecture in the sense of spreading its use in new markets. A critical impediment to its proliferation has been the barriers chip companies (beyond IBM, Freescale, and AMCC) have faced in creating Power-based systems-on-a-chip (SoC). IBM has worked with electronic design automation (EDA) companies Cadence, Mentor, and Synopsys to supply PowerPC cores for use in SoC development, and it teamed with Xilinx to produce an FPGA with an onboard PowerPC. However, PowerPC suppliers have yet to dent the success of ARM and MIPS, the leading suppliers of microprocessor cores, in SoC designs. One drawback to third parties using Power cores has been the lack of supporting infrastructure. In response, Power.org has two TSC: the SoC design and the bus architecture subcommittees. By standardizing the technological framework around Power Architecture, Power.org expects an ecosystem of collateral technology suppliers to emerge—enhancing the attractiveness of Power Architecture to SoC designers.

Power Architecture Strengths

In summary, Power Architecture has multiple strengths that position it to be a lasting species. Key among these are the strength of Power Architecture suppliers, the Power.org framework for evolving the architecture and its ecosystem, and the diversity of application markets in which Power has a strong presence.

Supplier Strength

The robustness of an architecture depends on the health of the suppliers that back it. Power Architecture's most important strength is that it is backed by two major semiconductor manufacturers: IBM and Freescale. Without IBM, there would be no Power Architecture enterprise servers. Further, IBM's willingness to create custom versions of Power Architecture chips and its leading-edge manufacturing capability uniquely position it to win high-volume designs such as game consoles. Similarly, Freescale's experience and presence in embedded systems markets such as communications and automotive have led to Power Architecture adoption there.

As Power.org enables more chip suppliers to base products on Power Architecture, the architecture will become more robust. The enablement of AMCC, for example, is an important step in this direction. AMCC is an established supplier of communications and storage products and will help proliferate the architecture in those markets. In particular, its RAID products stand to take share from Intel's ARM-compatible XScale RAID accelerators.

Managed Evolution

With IBM and Freescale joining together again, this time with other stakeholders, Power Architecture maintains the advantage of having multiple chip suppliers. It also gains the benefit of managed evolution, without which there is the risk that the suppliers, each pursuing its individual opportunities, will fork the architecture. Power.org has the mandate to reverse any existing divergence, which exists mostly at the system integration level, and systematize extensions to the architecture. Its challenge is to achieve the benefits of standardization through a process of gathering 360-degree input from the users, system designers, application developers, tool suppliers, and chip companies that belong to the organization without getting bogged down. Meeting this challenge yields the advantage that Power Architecture will adapt in advance of changes in technology and market conditions rather than in reaction to such change.

The diversity of companies in the Power Architecture ecosystem—suppliers of chips, software, or cores, customers, and users—gives the architecture tremendous potential for technology transfer. It also means a newcomer to the architecture is likely to find others with similar experience on which to draw and the baseline complementary technology already in place. If not, forming a partnership under the aegis of a TSC is relatively straightforward given the frameworks Power.org has put in place. The newcomer also benefits from participating in Power.org by being exposed to more potential customers. Moreover, the ecosystem benefits from the network effect: the value of the ecosystem is geometrically proportional to its size. As its value increases, it attracts more participants, thereby creating a virtuous cycle.

Application Market Diversity

Importantly, Power Architecture has adapted and spread to multiple application markets, providing a basis for further adaptation and proliferation. Although Power Architecture does not serve every possible market, it is used in the widest range of applications—from the world's fastest computers to the most deeply embedded real-time systems. Where Power Architecture is used, it tends to dominate. The main exception is personal computing, where it cannot match the ubiquity of the x86 architecture. It is not, however, endangered by x86, offering better performance and being the cornerstone of IBM's server business.

Application diversity is significant beyond leading to a more diverse ecosystem with its concomitant benefits. Few markets on their own are large enough to sustain an architecture; several must be aggregated to provide the minimum-sized revenue opportunity for the supply side of the ecosystem. Application diversity proves the architecture is suitable to new applications. For example, having proven itself exceptional at crunching numbers for multimedia applications, Power Architecture has displaced DSPs in military applications.

Application diversity also ensures an architecture's longevity. Even if Power were to lose ground in one application market, it would remain a vital architecture. However, it is possible for an architecture to be spread too thin. It is significant that Power Architecture tends to dominate its markets, because domination leads to the virtuous cycle of a growing ecosystem. It also leads to brand awareness within a segment; for example, the PowerQUICC name is nearly synonymous with "communications processor" to network system designers.

Conclusion

Because of the diversity of companies involved with Power Architecture and the diversity of applications that it serves, the architecture is well positioned to adapt and spread into emerging markets. Emerging opportunities are often the synthesis of two or more existing technologies. For example, telematics combines automotive, communications, computing, and sometimes multimedia processing. No other architecture participates significantly in all four areas. Another example is the digital home. Its two main ingredients are media processing and networking. With Power's domination of the game console market and strength in communications applications, the architecture has a beachhead in multimedia applications from which it can expand. While competing architectures have fared well in set-top boxes and home networking, increasing broadband rates and the revenue opportunity that games afford service providers give Power an advantage.

As a final example, network security systems have evolved to combine computing functions with the functions of real-time communications systems. The approach of combining a server with specialized add-in cards falters as network rates increase, cost pressures mount, and the number of layers of processing increases. This application requires a chip and software stack that provides the large memory address space and high-performance CPU found in a server along with the specialized processing capability of a communications system. Power Architecture excels on both fronts.

To address such opportunities, Power Architecture must evolve and proliferate. Power Architecture experts from one discipline must exchange ideas with those from other disciplines. Objectives for the architecture must be set and progress monitored. Arbitrary differences among different implementations of Power must be reduced. More companies—particularly SoC developers—must join the Power ecosystem. Power.org provides a structure for addressing these issues, and Freescale is a much-needed addition to the organization. Freescale's experience with Power Architecture complements that of existing members, and it has had a significant role in proliferating the architecture.

About The Linley Group

The Linley Group offers the most in-depth analysis of the networking-silicon and high-performance embedded microprocessor industries. We analyze not only the business strategy but also the technology inside all the announced products. Our in-depth reports cover topics including network processors, content processors, general-purpose CPUs, security processors, and communications processors. Our analysts have experience in product design, marketing, management, and industry analysis, allowing them to combine a deep understanding of technology with a strategic perspective on any issue. They cut through the hype to offer independent, unbiased recommendations. For more information, see our web site at www.linleygroup.com.