WP369 (v1.0.1) June 12, 2012

EPPs: The Ideal Solution for a Wide Range of Embedded Systems

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Delivering unrivaled levels of system performance, flexibility, scalability, and integration to developers, Xilinx's architecture for a new Extensible Processing Platform (EPP) is optimized for system power, cost, and size.

Based on ARM's dual-core Cortex™-A9 MPCore processors and Xilinx's 28 nm programmable logic, the Extensible Processing Platform takes a processor-centric approach by defining a comprehensive processor system implemented with standard design methods. This approach provides Software Developers a familiar programming environment within an optimized, full featured, powerful, yet low-cost, low-power processing platform.

System Architects and Logic Designers can fully leverage the programmable logic to extend, customize, optimize, and differentiate their solutions. The high-bandwidth AMBA®-Advanced Extensible Interface (AXI) interconnect between the processor system and the programmable logic enables multi-gigabit data transfers at very low power, thus eliminating common performance bottlenecks for control, data, I/O, and memory. This allows the ARM-based command/control/applications processing to take advantage of the programmable logic's massive parallel processing for handling large data payloads across a wide range of signal processing applications and/or the use of programmable logic to extend the features of ARM-based processor system.

The new Extensible Processing Platform is part of Xilinx's Targeted Design Platform strategy that provides customers market- and application-specific environments that are easy to use. This enables the customers to evaluate and understand platform capabilities and technology, using application platforms that can be modified and extended to accelerate development time, and to focus on differentiation.

This white paper describes the relevant challenges facing the semiconductor industry and shows how these can be solved with the Extensible Processing Platform. This breakthrough architecture, combining a high-performance, low-power, low-cost processor system, with Xilinx's innovative high-performance, low-power, 28 nm programmable logic is well suited for a wide variety of embedded system applications.

Industry Direction and Challenges - How to Differentiate

Processor-centric solutions, including microprocessors, ASICs, ASSPs, and applications processors, are a dominant force in today's semiconductor market. Many of these products are designed as system-on-chip (SoC) solutions, including a core processor engine that is complemented by common- and application-specific IP. Yet, with the continuing progression of Moore's Law, new product investments (see Figure 1) continue to escalate, resulting in fewer new product starts (see Figure 2) with products optimized for only the highest volume markets. This trend towards a commodity model limits customers' ability to optimize and differentiate, which makes achieving a competitive advantage an increasingly difficult goal.

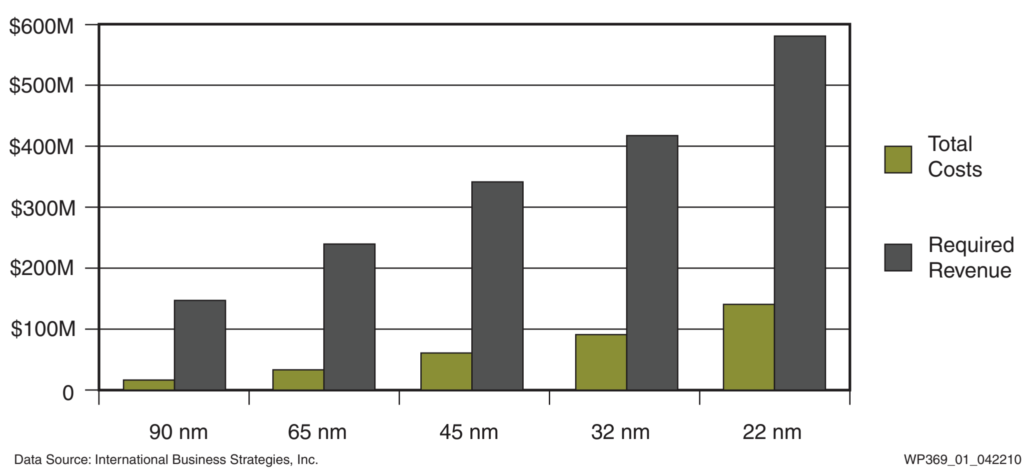

Figure 1: **New Product Financial Breakeven**

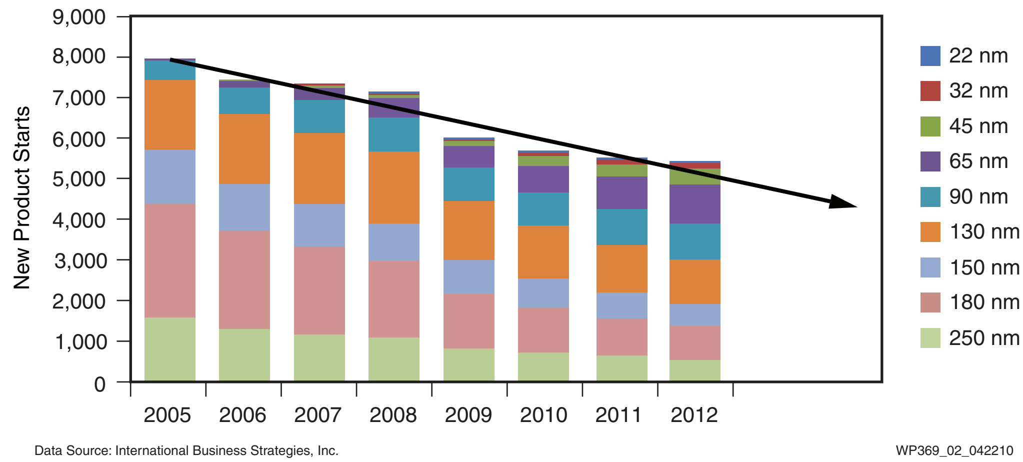

Figure 2: **Declining Product Starts**

Programmable logic solutions like Xilinx FPGA's provide the hardware flexibility to optimize and differentiate and are ideal for handling the parallel computing required for advanced digital communications and video. They have not historically been optimal for running complex operating systems and application software and are not offered in a familiar programming environment for Software Developers.

A processor-centric solution with programmable logic is an ideal combination to meet both the software and hardware programmable needs. System Architects can optimize and differentiate their systems; Logic Designers can add features and extend capabilities/performance; and Software Developers can program in a familiar environment to apply their applications and manage the entire system.

Extensible Processing Platform Definition - the Engine of Innovation

As the name implies, the processor is central to this approach, and it must appeal to the System Architect, the Logic Designer, and the Software Developer alike.

Selecting the right core processing platform is critical. Performance, cost, power, tool chain, and the supporting ecosystem are vital elements in determining the best candidate. Framing this selection are the target applications that encompass advanced digital communications, image processing, command/control, test systems, etc. Given the parallel computing power of programmable logic, the processor has to possess similar capabilities to enhance system performance.

While there are many worthy processor options, Xilinx’s choice is ARM's dual-core Cortex-A9 MPCore processors. Recognizing that ARM is the de facto standard for high-speed, low-power microprocessor cores, ARM's supporting IP, third-party ecosystem, and broad software base meet all of Xilinx’s key criteria.

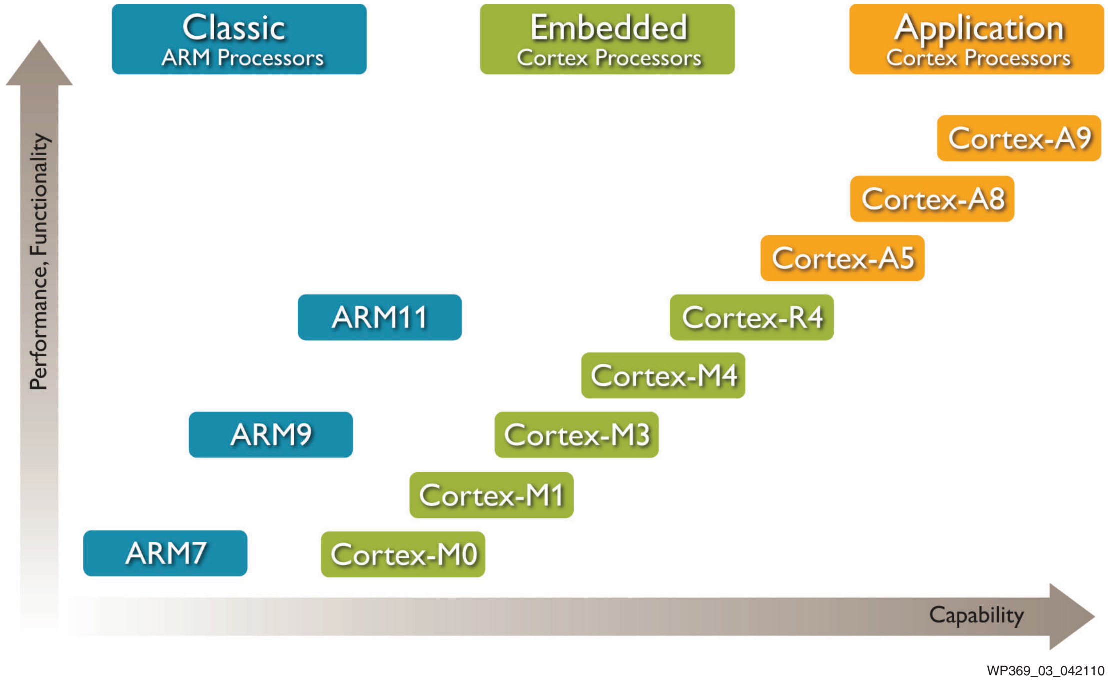

Figure 3: **ARM Processor Roadmap**

With a processor-centric approach, the platform behaves like a typical processor solution that boots on reset and provides Software Developers a consistent programming model.

To achieve this, the Processing System (see Figure 4) is fully integrated and hardwired, using standard design methods, and includes caches, timers, interrupts, switches, memory controllers, and commonly used connectivity and I/O peripherals. The processor system boots on reset and can run a variety of operating systems (OS) at power-up. With this approach, the software programming model is set within an optimized, full featured, powerful, yet low-cost, low-power ARM-based processing platform.

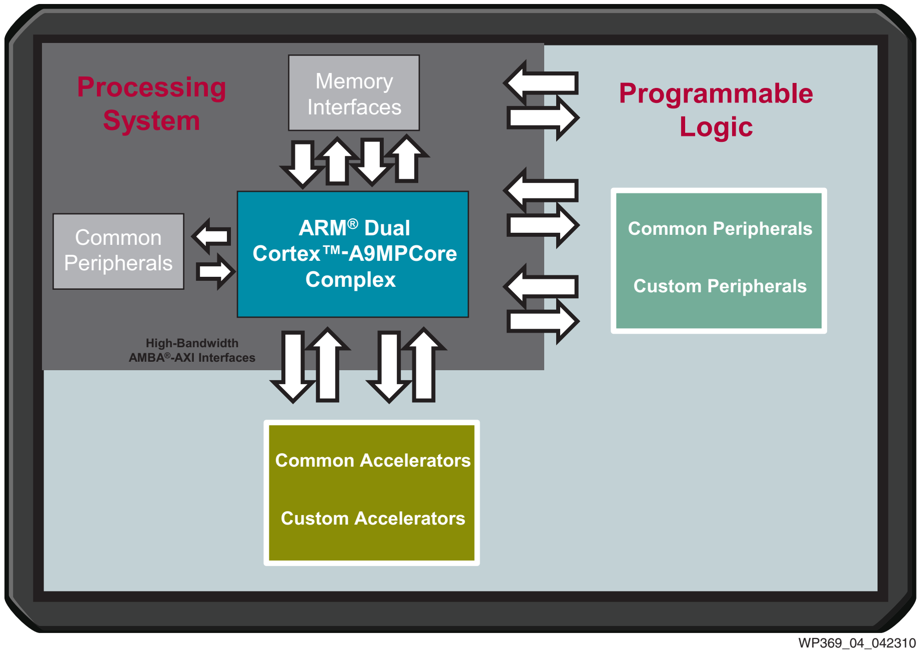

Figure 4: **Extensible Processing Platform**

With an optimized Processing System available, System Architects and Logic Designers can focus their energy on system optimizations, algorithms, and feature extensions to differentiate their products, utilizing the tightly coupled high-performance, low-power 28 nm programmable logic (Figure 4).

For more information on Xilinx's 28 nm technology, see: http://www.xilinx.com/technology/roadmap/28nm-technology.htm.

Extending the Processing System requires a tight coupling with the programmable logic to ensure a seamless interface in terms of performance, configuration, and programming. Extensibility is enabled by the use of high-bandwidth AMBA-AXI interconnects (Figure 4) between the Processing System and programmable logic for control, data, I/O, and memory. Not only does this provide the ability to transfer massive amounts of data rapidly at extremely low power, but it unifies the hardware and software programming domains.

Further, in the March 2010 release of version 4 of its AMBA Advanced Extensible Interface (AXI), ARM included an extension of the AXI specification optimized for programmable logic, co-developed with Xilinx. The AXI-4 Stream protocol extension serves as a bidirectional crossbar communication switch that utilizes these interconnects. This enables engineers using the new Extensible Processing Platform to achieve new levels of system inter-block throughput while tapping into a multitude of hardware peripheral cores that IP vendors and customers have developed for other ARM implementations over the last two decades.

For more information on AMBA technology, see:
http://www.arm.com/products/system-ip/amba/index.php.

This tight coupling also gives the Processor System full configuration control of the programmable logic, including partial reconfiguration. The Processor System can reprogram parts of the programmable logic through software as needed to meet varying system operating environments. Configuration control is a powerful feature in that it allows for adaptive solutions based on real-time conditions while conserving available resources by multi-purposing them.

Integration also benefits the embedded systems by eliminating separate packages, components, and potentially other devices. The net effect is an overall reduction in system BoM, power, and size, with dramatic increases in performance, flexibility, and differentiation.

While the Processing System is fixed, the programmable logic can be sized from a few thousand to several hundred thousand logic cells. Xilinx plans to offer a range of Extensible Processing Platform products that enable customers to scale across their portfolios by changing the part and reprogramming the device. This range will provide customers a common platform to scale from low-cost, low-power systems up to feature-rich and performance-driven solutions.

This architectural combination of industry-leading technologies gives the Extensible Processing Platform an unrivaled mix of serial and parallel processing, flexibility, and scalability, enabling a more optimized and potentially revolutionary system partitioning—especially in the areas of intelligent video, digital communications, machine systems, and medical devices.

For customers who want to differentiate or need to develop application-specific IP, the Extensible Processing Platform provides the ability to program system features, algorithms, and extensions needed in both hardware and software.

This unique combination of sheer performance, optimized power, and cost, combined with flexibility and scalability, will yield significant savings for customers in terms of development cycle time, resource investment, and definition risk avoidance. It also provides System Architects, Logic Designers, and Software Developers a unified platform to develop their next generation products. And by leveraging ARM's technologies and Xilinx's Targeted Design Platform strategy, a vast base of developers and IP will be readily available to provide industry solutions, further improving costs, schedules, and risks.

Software-Centric Flow - Unifying System Development

Programmable logic device such as Xilinx's FPGAs are well supported by sophisticated tools suites. These tools provide the Logic Designers an environment rich in features to optimize their IP solutions and render them onto the silicon devices. In this environment, the programming languages are hardware-oriented such as Verilog and VHDL.

Software Developers work almost exclusively in high-level languages, such as C/C++, which are also well supported by today's processor-based solutions.

In the Extensible Processing Platform, Xilinx will enable support for familiar software development and debug environments, using tools such as ARM Real View and related third-party tools, Eclipse-based IDEs, GNU, Xilinx® Software Development Kit, and others. The programmable logic portion can be developed and debugged using the standard ISE® Design Suite, and other third party HDL and algorithmic design tools.

Because the Extensible Processing Platform takes a processor-centric approach (it boots the Processing System at reset and then manages the programmable logic configuration), a more software-centric development flow is enabled (Figure 5).

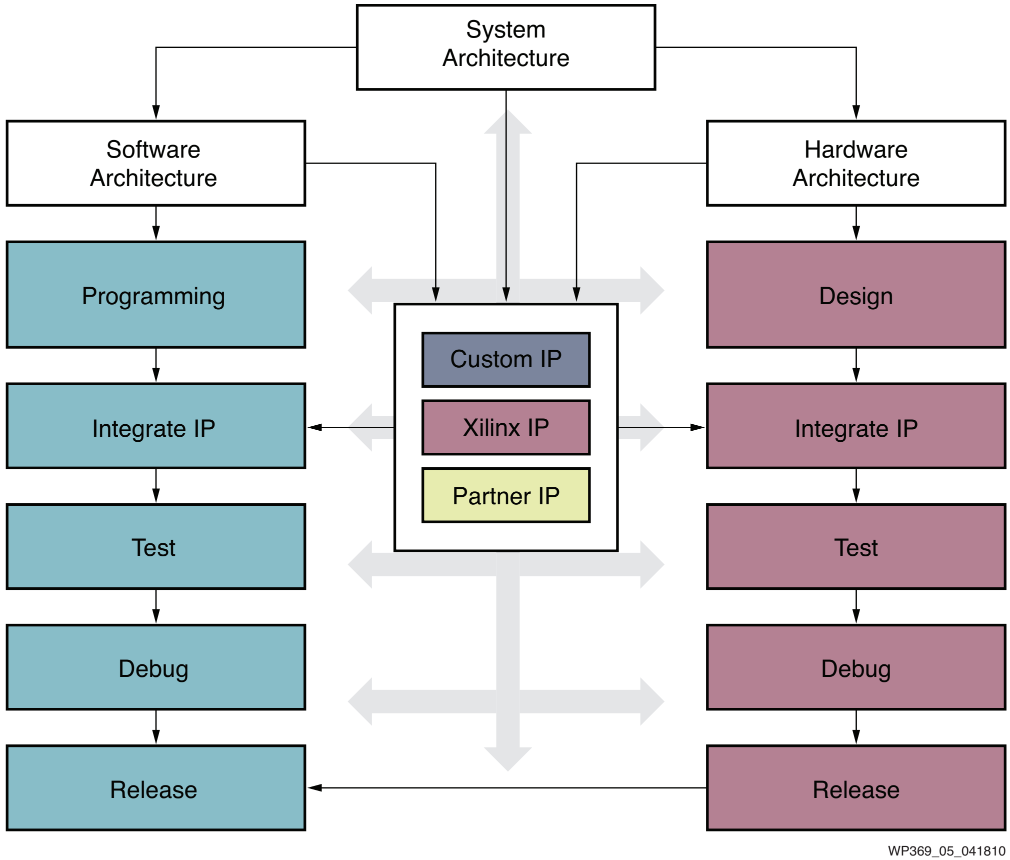

Figure 5: **Software-Centric Development Flow**

This flow enables the System Architect, Logic Designer, and Software Developer to work in parallel, using their familiar programming environments, then merge the final releases into the software baseline. As a result, key partitioning decisions on system functions/performance can be made early and throughout the development process. This is critical for embedded systems where application complexity is driving tremendous levels of system performance against tightly-managed cost, schedule, and power budgets.

System Architects and Software Developers typically define the system initially from the software perspective and then determine what functions they need to offload or accelerate in hardware. This allows them to trial fit their design against the performance, cost, and power targets of the application.

At this proof-of-concept stage, System Architects and Software Developers are most concerned with having flexibility over what can be performed in hardware or run in software to meet the specific application requirements. Iteratively, they converge on the optimal partitioning of hardware and software, and then refine both to fit the system requirements. The Extensible Processing Platform is ideal for this process as it will accelerate convergence on a more idealized programming platform.

It is important to note that the AMBA-AXI interfaces are key in enabling the software-centric flow because they present a seamless, common, and well-defined environment for the hardware extensions. While the Logic Designer will need to deeply understand this technology, for the Software Developer, the AMBA interfaces abstract the extended logic as memory mapped calls. This allows for a straightforward interplay of hardware and software programming in a parallel state of development.

Software and Solutions - Leveraging the Industry

The adoption of ARM technology is part of Xilinx's move to embrace open industry standards and to foster development of system solutions. Xilinx's Targeted Design Platform strategy is ground-zero for these initiatives and unites these efforts with those of key third parties to provide Xilinx customers a robust ecosystem to complement their development efforts. For more information, go to: http://www.xilinx.com/products/targeted_design_platforms.htm.

These well-formed strategies mean the Extensible Processing Platform will be able to leverage industry-leading tools, software, and solutions, enabling customers to simplify and accelerate embedded systems development and achieve competitive advantages.

Along with the capability of running a wide variety of operating systems, such as Linux, Wind River's VxWorks, Micrium's uC/OSII, and many others that will support the Cortex A9, the Extensible Processing Platform will be able to utilize the vast off-the-shelf open source and commercially available software component libraries as well as ARM-based legacy code.

Xilinx will provide software unique to the Extensible Processor Platform, such as drivers, stacks, and APIs.

Logic Designers will also be able to tap into the availability of ARM-based IP from a host of industry sources as well as system solutions developed in conjunction with Xilinx's Targeted Design Platform or other third-party system suppliers.

For system analysis and verification, Xilinx is working with third-party vendors to provide simulation tools, including bus functional models and full verification IP. More advanced simulation tools are being considered as well.

Longer term, Xilinx is working with a third party to develop C-to-FPGA compiler flows in an effort to eventually offer System Architects and Software Developers a way to easily move functions between software and hardware and rapidly develop, evaluate, and optimize their systems. In fact, Xilinx has partnered with the benchmarking and analysis firm BDTi to accelerate the use models of C-level synthesis tools. For more information, go to: http://www.bdti.com/articles/info_articles.htm

Target Applications and Markets - Performance, Flexibility, Efficiency

Higher levels of embedded system performance are being driven by end market applications that require multi-functionality, high-speed signal processing, and real-time responsiveness. Applications such as intelligent video (driver assistance, surveillance, and automation), next generation wireless (enterprise Femtocells, 4G Basestations), aerospace/defense (telemetry and guidance), and broadcast (cameras, content, and transmission) possess several common requirements including:

- Advanced decision and control processing
- Complex user or control system interfaces
- Multiple inputs of complex data
- High-performance, low-latency signal processing

In addition, many of these applications are under pressure to meet tighter and/or evolving requirements or offer portfolios that scale from cost-effective to feature-rich solutions.

In the automotive sector alone, the driver assistance market is expected to grow to $5.8 billion by 2017[1]as manufacturers deploy more embedded systems in their vehicles to make them safer. Statistics show that 60 percent of front-end collisions could have been avoided with an extra 0.5-second response time, and that driver fatigue accounts for an estimated 30 percent of all driver fatalities.

The motivation to leverage technology to save lives is clear. The Extensible Processing Platform is ideal for these automotive applications. It is able to readily interface to the latest sensor technology, process multiple digital signal inputs (video, radar, infrared, etc.) via the high-performance parallel processing of the programmable logic, and rapidly pass that data to the ARM Processing System to assess, compare, react, and communicate within the framework of the automobile's electronic systems.

Furthermore, automotive designers will be able to update/enhance their systems and algorithms once deployed. As a single-chip solution, system cost, power, and size are optimized, which enables systems to be adapted into tight quarters within the automobile.

Surveillance requirements are also driving high-performance, low-cost, low-power demands. Surveillance applications provide distributed/remote intelligent video systems that can monitor, analyze, compare, and decide on appropriate actions such as communicating with a home base, activating a digital video recorder, alerting authorities, sounding alarms, etc. These systems need 1080p60 capabilities, faster processing, and thorough analytics along with command, control, and communications functions packed into small, cost-effective systems with limited power supplies

The Extensible Processing Platform will be able to meet these surveillance needs and support the remote refresh imaging algorithms, analysis, and camera control so that systems can be adjusted as needed to meet the needs of the user or the local environment. Customers will have the ability to offer a broad range of smart cameras, allowing them to scale their investments across a greater revenue base.

Wireless telecommunication applications are also being driven by lower power, combined with smaller physical form factor and reduced development costs, as they support an ever increasing number of users and data hungry applications. New technologies such as 4G long term evolution (LTE) can address bandwidth requirements, but smaller, more efficient base stations are essential to meeting overall market requirements.

The Xilinx Extensible Processing Platform will help developers of next-generation wireless base stations to meet these needs by providing high bandwidth parallel processing of 4G signals in combination with multi-user data management on the Cortex A9 processors - all in a small, power-efficient, cost-effective integrated solution. Like the previous examples, developers have the flexibility to implement future updates and performance upgrades of both hardware and software.

These are just a few examples of where and how the capabilities of the Xilinx Extensible Processing Platform will be applied.

1. Intelligent Car Initiative–Europe's Information Society; International Organization of Motor Vehicle Manufacturers; see http://www.worldometers.info/cars/.

Summary

The combination of ARM's dual-core Cortex-A9 MPCore processors and Xilinx's 28 nm programmable logic presents a tremendous amount of serial and parallel processing power. The AMBA AXI interconnects harness these capabilities while the Extensible Processing Platform architecture enables them to be fully utilized to maximum effect.

By adopting a processor-centric approach and defining a fixed Processing System with programmable logic extensions, Xilinx optimized the Extensible Processing Platform for use by the System Architect, Logic Designer, and Software Developer. This yielded a software-centric development flow that fits the traditional system development model for optimizing hardware and software partitioning, which will enhance development cycle times and overall system performance.

System development is further enhanced through both ARM's and Xilinx's IP and ecosystems. The availability of world-class development/design tools, software, IP, and platform solutions provides developers a familiar programming environment and launching pad to build their solutions.

Total system power, cost, and size are addressed in multiple ways:

- ARM is the de facto standard for high-speed, low-power microprocessor cores
- A fixed Processing System leverages standard design methods to optimize throughput, area, and power
- Xilinx's 28 nm high-performance, low-power programmable logic is fast, efficient, and cost effective
- A processor-centric approach puts software in charge, enabling various low-power states and configuration options
- Integration of the Processing System and programmable logic enables very high data rates at very low power, eliminating extra components and chips
- A single platform scales and is used in multiple products, reducing procurement expenses, inventory, and obsolescence

These factors coupled with the flexibility offered by both hardware and software programmability, enable customers to reduce development times and investments, resulting in improved financials and faster time-to-market and time-to-money. Furthermore, system definition risk is greatly reduced and possibly eliminated while upgrades/updates are enabled, making it easier to service systems and end customers.

Unrivaled performance, optimized partitioning, lower power, lower cost, lower risk, improved financials, system flexibility, scalability, upgrade-ability, supported by world-class tools, ecosystems, IP based on industry open standards and familiar programming environments—these are compelling attributes.

Yet, as the semiconductor industry trends towards a commodity model, perhaps the most compelling attribute of the Extensible Processing Platform will be the customer's ability to build a solution that meets their unique needs and differentiates their solution from their competition.

Revision History

The following table shows the revision history for this document:

Date	Version	Description of Revisions
04/27/10	1.0	Initial Xilinx release.
06/12/12	1.0.1	Minor typographical edits.

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