Introduction

Today’s complex Aerospace and Defense (A&D) applications demand embedded computing systems that not only deliver reliable data transfer and retrieval, but deliver it in size, weight and power (SWaP)-optimized low cost formats ready for deployment across a range of vehicle platforms. With increasing budget pressures and the multitude of high performance, high cost products on the market, finding a lower cost alternative embedded solution that offers good performance, low power, and high integrity may seem arduous. Historically, Intel® has dominated the microprocessor market with its high cost, highly complex x86 family of chips. However, in recent years Intel’s x86 has been greatly challenged in the marketplace by streamlined ARM-based technology, which is not only lower cost, but offers enviable size, weight, power and cost (SWaP-C) advantages. This white paper will discuss ARM processor technology and its use within A&D applications.

Cost, SWaP, and Processing Options Driven by Broad Commercial Markets

Embedded processing for the A&D industries faces unique SWaP constraints as well as cost limits imposed by program budgets. COTS products meet these twin demands by using processors developed for broad commercial markets, with costs set by competition within those markets, then addressing the SWaP issues with innovative designs at the module and chassis level.

For years, Power Architecture® processors provided the optimum balance of performance, cost and SWaP characteristics for Commercial Off the Shelf (COTS). However, more recently the Intel x86 family has driven chip performance to new levels, defining price points for the worldwide PC market. COTS products have implemented the x86 processors, exploiting the performance and innovating advanced thermal designs to compensate for the x86’s increased power and heat issues.

A new processing option is now available, driven by the exploding commercial market for mobile devices. The ARM architecture delivers performance that meets the needs of many applications, especially mission computing, while also offering the low cost, low power characteristics driven by the mobile market.
What is ARM?

Advanced RISC Machine (ARM) processor technology is based on 32-bit RISC (Reduction Instruction Set Computing), a simplified instruction set architecture that requires fewer microprocessor cycles per instruction. RISC architecture results in a processor that produces the best MIPS (Million Instruction per Second) to watt ratio, which operates on less power, and ultimately can be manufactured at a lower cost. Because of the simplified nature of RISC, ARM-based processors can be produced in a small physical size, making ARM an ideal choice for SWaP-constrained applications. In addition to the 32-bit technology found in the popular Cortex®-A5 through Cortex-A17 processors, ARM is currently developing high performance Cortex-A5x with ARMv8-A 64-bit architecture, which will maintain compatibility with, and low power benefits of its 32-bit predecessors while extending the range of performance.

Figure 1: Dual ARM® Cortex®-A7 core processor, courtesy of Freescale

ARM itself does not make processors, but rather licenses its technology out to leading silicon manufacturers including Freescale™, NVIDIA®, Apple®, and Samsung. However, ARM is not just for mobile devices or micro-controllers. For example, Freescale has taken ARM into the communication market, where high performance and low power is a required pairing. Worldwide, ARM is currently the most widely produced instruction set architecture, and the most popular 32-bit architecture for embedded computing systems, far surpassing all its competitors in the 32-bit market space. As ARM technology has matured in recent years, the military-aerospace market has taken notice and is beginning to reap the undeniable benefits of what ARM has to offer.

The Complexity of Intel

For the better part of three decades, Intel commanded the lion’s share of the microprocessor market, holding customers captive with full control over the well-known Windows® platform. Because of the demand for Windows-based computing, Intel has been successful in charging PC manufacturers top dollar for its x86 chip, setting high market prices and dictating when and how updates to x86 chips are made.

While cost is an issue, the more significant problem with the x86 technology stems from years of backward compatible upgrades supporting legacy constructs. Designing for backward compatibility means the x86 requires a bigger core and more transistors to accommodate its functionality, while a bigger core translates into a chip that consumes more power and releases more heat. In addition, Intel’s x86 chips use CISC (Complex Instruction Set Computing) architecture, which greatly adds to the core’s complexity. All these factors combine to make the x86 chip a high-cost, multi-layered, overly complex resource, failing to meet the integral low-power, low cost needs of many deployed embedded computing applications.

The Benefits of ARM

Given the complexity issues with Intel's x86 chip, it’s no surprise that ARM-based technology now outsells Intel’s x86 by more than 10 to 1, addressing the x86 chip downsides, and providing a low power, high integrity processor option for cost-constrained mission applications. ARM’s 32-bit (and upcoming 64-bit) versions perform far beyond the level required to run most mission computer applications, and because of this, ARM is rapidly gaining popularity in venues such as embedded computing where the combination of small form factor, low power, and high performance is paramount.

Figure 2: X86 vs. ARM market share thru 2013, courtesy of The Register
Low Power SWaP-Optimized Design

ARM processors deliver better power dissipation for a number of reasons. The RISC architecture, which requires a smaller transistor count, allows for efficient data transfer to occur in a smaller core than its CISC counterparts. For example, ARM’s Cortex-A9 processor has a 26 million transistor count, while the current Intel x86’s count is over one billion. Even Power Architecture’s MPC7448 processor, with a 90 million transistor count, cannot beat ARM’s desirable architectural simplicity. In addition, the legacy support needed on the x86 chip requires Intel processors to support larger cores, using more overall power and dissipating more heat than ARM’s compact design.

ARM processors reduce power consumption by operating at a lower clock frequency than the x86 or Power Architecture processors. Additionally, the ARM SoC (System on a Chip) vendors have integrated many low power states such as power gating and clock gating into their processors. Given these characteristics, the ARM architecture provides users with the highest performance per watt, while maintaining all the necessary computing capabilities. ARM’s lower power design lends itself nicely to SWaP-constrained applications by providing a reduced thermal solution, in a low-weight processor. The end result is a package size that is suitable for Single Board Computer (SBC) solutions in 3U and mezzanine form factors.

Low Cost

One of the most desirable features of ARM-based technology is its low cost as compared to its competitors. ARM’s simpler architecture, lacking all of Intel’s backwards compatibility complexities, allows for ARM processors to be produced with much smaller footprints than Intel’s x86 chip, and at an overall lower manufacturing cost. ARM’s ability to integrate highly flexible extensions and options allows for all the necessary computing functionality to be present, while maintaining affordability. ARM’s low power capabilities also reduce the overall cost of thermal management. ARM easily provides the best MIPS to cost ratio available on the market today, far surpassing anything that can be offered by x86 or Power Architecture competitors. In addition, the multitude of vendors offering ARM-based solutions ensures healthy competition in the marketplace, which plays a key role in keeping processor price points in check.

Curtiss-Wright’s ARM-based VPX3-1701 SBC

For A&D applications requiring high integrity, low cost SBC delivering unparalleled performance per watt, Curtiss-Wright has introduced the VPX3-1701 Dual-ARM Cortex-A7-based SBC with NEON core. The VPX3-1701 utilizes the performance, low power and advanced I/O capabilities of a highly-integrated ARM Cortex-A7 processor to provide a highly capable processing and data management platform for a wide range of harsh environment embedded applications. Designed for SWaP-C-constrained applications, the VPX3-1701 represents the latest step in processor evolution, bringing low power ARM processing to 3U VPX™ SBCs, combining the required I/O and system integration features with highly efficient performance.

Figure 3: VPX3-1701
VPX3-1701 SBC

The VPX3-1701 utilizes Freescale’s LayerScape LS1020A architecture, an outstanding 32-bit, core agnostic, multicore SoC on the same QorIQ™ platform as may Power Architecture SBCs, providing the board with the high-efficiency and scale required of modern applications. The LS1020A processor offers the I/O required for SBCs including x4 Gen2 PCI Express® (PCIe), and excels in power efficiency and extensive integration for fan-less, small form factor applications. Freescale is a leading provider of ARM microprocessors, one of the largest licensees of ARM technology, and has an outstanding track record supporting the embedded computing features required in the A&D market segment. Freescale proudly holds a CoreMark® benchmark performance of over 5,000 under 3.7W and enjoys the industry’s best CoreMark/mW ratio. Freescale develops LayerScape devices supporting both Power Architecture and ARM with common I/O, making it quick and easy for Power Architecture users to become familiar with their ARM-based products. The LS1020A architecture used on the VPX3-1701 also benefits from Freescale’s Product Longevity Program, which ensures a device will be shipped for at least 10 years from product announcement.

A special characteristic of the ARM Cortex-A7 implementation in the LS1020A used on Curtiss-Wright’s VPX3-1701 is the addition of ECC throughout the L1 and L2 cache. This functionality typically does not appear on cores earlier than Cortex-A15. Curtiss-Wright specifically selected the LS1020A architecture to include this advanced ECC functionality on a Cortex-A7 processor. With ECC on the internal cache memory as well as the external memory, the VPX3-1701 offers the same high integrity computing as comparable Power Architecture processors, but at a reduced price.

The rugged, conduction-cooled VPX3-1701 enables multi-GBps data flows that support the acquisition, processing, and distribution of sensor data for demanding C4ISR applications such as video, radar, and sonar data processing. With low power and low cost, the VPX3-1701 is ideal for customers looking to upgrade from CompactPCI® (cPCI), and also provides an optimal migration path for those using MCU-based designs.

A Look to the Future

ARM-based technology has revolutionized the microprocessor industry, resulting in better development tools, more middleware, and broader system support. ARM architecture skillfully addresses SWaP-C constraints in a high performance, low power, low cost package ideal for deployed vehicle platforms. Curtiss-Wright’s ARM-based SBCs are the industry’s first VPX architecture processing modules to harness the affordability and low power advantages of the ARM architecture, providing A&D applications with unmatched performance-per-watt without compromising full-featured connectivity and I/O options. The VPX3-1701 is the first ARM roadmap product that Curtiss-Wright has introduced, and we are committed to continuing our ARM-based offerings with 64-bit ARM processor SBCs that support high bandwidth communication links and integrated graphics capabilities. Contact Curtiss-Wright to find out how you can benefit from the power of ARM technology.
Author

Greg Sikkens
Product Marketing Manager
Curtiss-Wright Defense Solutions

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VME Single Board Computers Upgrade Guide