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» Whitepaper «

Military Design Trends: Applications Migrating to Intel x86 Architecture

If it's embedded, it 's Kontron.

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Today's military and defense systems designers are seeing the inherent benefits of Intel® x86 Architecture for new designs as well as legacy applications that have started to migrate from other processor architecture technologies. This is due in part to Intel's strong roadmap that takes into consideration the special technology requirements that are now demanded to support modern battlefield capabilities. Intel's approach to processors meets or exceeds this market's stringent requirements for low power, superior performance, increased longevity, improved ruggedness and cost considerations. In addition, Intel's use of multi-core processors – expanding the number of cores available on a single ASIC – are available on a variety of platforms used in military systems, ranging from Computer-on-Modules to VME and CompactPCI to the newest VPX implementations. Beyond these benefits, designers have also realized that when designing x86-based systems, they can capitalize on the proliferation of inexpensive Windows-based software instead of the more expensive approach of purchasing or developing application-specific software.

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As part of Intel's embedded roadmap, its 45nm microarchitecture has had a decisive impact on the future of military systems and the growing migration to x86. Each time Intel achieves process advancements, the architecture gains efficiency and the power-to-performance ratio improves, giving more designers the incentive to convert to Intel Architecture from other processing technologies.

This paper will examine the tenets that make Intel x86 Architecture, which is further enhanced by 45nm multi-core technology, particularly well-suited to the unique requirements of military and defense systems as well as the embedded technologies that support them.

Military Technology Initiatives Driving Migration

Modern battlefield initiatives are driving significant technology evolution across the full range of military forces. Programs such as the Army's FCS (Future Combat Systems), JTRS (Joint Tactical Radio System) and WIN-T (Warfighter Information Network – Tactical), require significantly greater bandwidth, far beyond technologies found on earlier battlefields, and are an ideal fit for the power, performance and value represented in Intel x86 Architecture. Application requirements are diverse and range from weapons control to handheld GPS-based radios to man-wearable control units for military robotics to real-time sharing of surveillance data – demanding high performance and reliability as they typically link individual soldiers to any number of vehicles, aircraft, ships or command centers.

Designers today are faced with not only creating new, high-bandwidth solutions, but also migrating older systems to meet the military's enhanced levels of ruggedness and performance. As a result, many legacy systems are moving to Intel Architecture through both hardware and software implementations.

Trusted partners to the military and defense developer community, Intel and Kontron have leveraged a close alliance to support designers who are migrating to x86. As a key supplier of Intel-based products and a Premier Member of the Intel® Embedded and Communications Alliance, Kontron offers designers unmatched engineer-to-engineer knowledge and design expertise – supporting migration designs well beyond a typical manufacturing partner relationship.

Why to x86?

It's an imperative for defense system suppliers to keep up with technology requirements of the modernized battlefield. At the same time, designers must work within the specific constraints of military contracts and budgets – which include more than monetary cost, and also have to contend with time-to-market pressures to stay competitive. Upgraded or new solutions must be developed, certified and deployed within specific timeframes that meet the exact requirements of military technology initiatives.
Migrating to a new processor architecture may come into consideration when defense groups request a change or improvement in capabilities of an existing system. Designers may also be tasked with a new project or RFQ, and are taking special care to answer these requests competitively and well within the tolerance of key customer issues. Power (the lower, the better), performance (the higher, the better) and cost are frequently the top issues that drive a designer to evaluate and create a migration design.

End of Life (EOL) issues are another critical migration driver. EOL notices for major parts, such as an SBC, are common and require immediate attention, particularly if long life supplies were not managed earlier in the lifecycle of the existing system. Fifteen years of support is typical for military systems and such long-term supplies require proactive steps to maintain. Frequently that does not happen and customers require a redesign to replace an obsolete product, either with a new product or a new product from an alternate vendor. These situations are opportunities for designers to move to Intel x86 Architecture, taking advantage of the company's proven and highly efficient slate of embedded products.

Manufacturers such as Kontron work with designers to take required steps to offer long term support and extend the availability of certain parts. After the initial five to seven years guaranteed by Intel's Embedded Roadmap, Kontron can offer special arrangements to keep stock on hand and guarantee long life as required by military design guidelines.

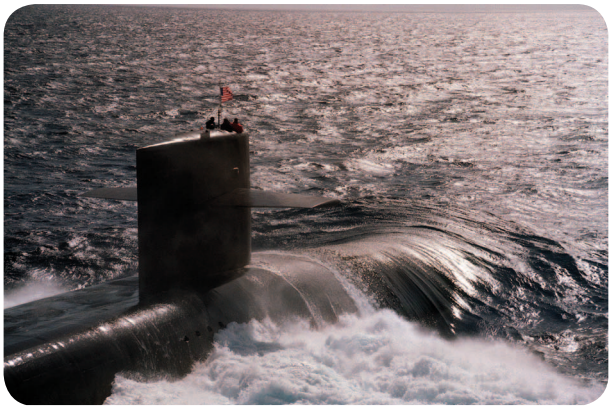
Important Hardware and Software Considerations for x86 Migration

Software is frequently the more costly and potentially more challenging of the two sides of design, and is considered an art form by many embedded designers. The development path can vary significantly from designer to designer and ultimately there are numerous ways to get it right. Knowledge, not only of programming rules and languages but also of the end use of the application, has a critical impact on how the software is developed and what role that plays in determining the migration to x86-based architecture. Software development, the tools to support it, and the speed with which designers can make a smooth transition and get to market are key issues in these migrations, and frequently are the primary influencers in the choice of architecture.

Intel's full line of development products help implement, debug and tune software for performance and correctness, as well as shorten the time-to-market cycle. Open source initiatives, such as Linux, and Intel's ongoing support for development tools from major independent software vendors (ISVs) and operating system vendors (OSVs) are valuable considerations for designers planning to migrate to x86. All designs call for individual considerations, but in general, designers evaluate multiple software design areas including several hardware architectural differences, operating system, system initialization, and migration and development tools. One key migration issue, for example when moving from PowerPC to x86, is moving from a uniprocessor serial code to a multi-core software system. Additional software development tools, such as NASoftware, allow conversion of existing, highly optimized AltiVec DSP instruction sets and syntax to be very effectively handled by Intel multi-core processors.

Intel's technology initiatives also drive a strong ecosystem of independent hardware vendors (IHVs) that supply standards-based products in a wide range of form factors, allowing designers to focus on their core competencies and competitive approach. For example, the relationship between Kontron and Intel ensures that customers will see the latest processors on Kontron boards as soon as Intel launches those products. With each power-to-performance improvement, Kontron will in turn capitalize on Intel's process shrinks to develop higher performing and lower power boards and systems available for x86 migrations and designs.

When migrating any design, the first step is a careful examination of the existing system, including not only the products and boards integrated but the end use feature sets. Technologies used in the existing system will impact the recommendations made by any new supplier. For example, if a design uses single instruction-multiple data (SIMD) processing, such as within PowerPC Architecture, designers must understand how to achieve the same result with the Intel instruction set. I/O details are critical as well, since options there represent an incredible range of possibilities and will vary depending on the communication and networking requirements of the system. Also critical is the form factor and whether it is necessary to migrate to a smaller footprint or lower power threshold and still attempt to maintain the performance level.



Cores or Chips

Multi core processing from Intel includes one ASIC powered by multiple executing cores. Competing products include a dual chip version (multiple processors achieved with two individual ASICs built into the board). For many years Kontron and other manufacturers have offered multiple processors via multiple chips, such as on a 6U SBC. Intel's dual core, all-in-one chips are designed to run symmetrical multiprocessing, meaning just one kernel runs both engines of the ASIC, whereas dual chip boards require an operating system for each chip, 'snugly coupled' and sharing resources. In these instances, software must be written so the resources are neatly allocated between the chips and neither chip 'starves.' There is some design overhead in terms of performance for snugly coupled chips, communicating through a variety of software methodologies. The cores within a single multi-core chip must also communicate, but transit time for data is much closer and enabled by Intel's 45nm microarchitecture.

45nm and Counting

New 45nm processor production represents Intel's fastest product ramp to date, and includes single core Intel® Atom™ processors, dual core Intel® Core™2 Duo processors, Intel® Core™ i7 processors with four cores, and the 6 core Intel® Xeon® processor. Compared to 65nm technology, Intel's hafnium-based 45nm high-k metal gate silicon process technology offers approximately twice the transistor density to deliver more than a 20 percent improvement in transistor switching speed, and reduce transistor gate leakage by over 10-fold.

The recently introduced 45nm Intel® Atom™ Z5xx series processors offer robust performance per-watt in an ultra-small 13x14 mm package. With lower voltage levels and lower FSB speed than the Intel® Core™ 2 Duo processor, CMOS drivers can now be used, drawing less power than predecessor GTL drivers. The Intel® Atom™ processor also dynamically reduces chip cache size to save power. The processors are validated with the Intel® System Controller Hub (SCH) US15W chipset, which integrates a graphics memory controller hub, and I/O controller hub into one small 22x22 mm package. These advanced power management capabilities enable the lowest possible platform power consumption. According to Intel, the two-chip platform provides more than 80 percent reduction in total footprint over the previous-generation three-chip solution, with a combined thermal design power under 5 watts. Designers can also expect a 32nm microarchitecture, as well as a single chip solution, both on the development horizon. This deeper level of integration has significant impact – when high-powered performance requires less physical space, designers can include more on their boards.

Designing Competitively With x86

Designers are notably migrating to x86 in the 3U CompactPCI and 3U VPX platforms, shifting easily from 6U VME implementations. Many designers are taking the opportunity to upgrade the backplane in the migration process, gaining bandwidth and performance features by moving to CompactPCI and VPX. This represents a change in design thinking; although they cannot put as much on each card, designers have more room due to moving to a smaller form factor. Processors with faster clock rates and increased power-to-performance ratios means they can pack the same performance in a much smaller volume. Overall though, Intel x86 Architecture is form factor-agnostic and applies readily to any number of the military's favorite platforms. Computer-on-Modules, VME, CompactPCI and VPX are deeply entrenched in military design, and all are recognizing great gains from the processor benefits available through an Intel Architecture foundation.

Power Consumption

Power-hungry military applications have long been a challenge for the embedded designer. Intel's Architecture featuring multi-cores provides a power-sensitive blueprint for enhanced energy-efficient performance that helps balance processing capabilities within power and space constraints.

The Intel® Atom™ processor, for example, is optimized for very low power consumption and comes in a variety of design options, power levels, package sizes, and temperature ranges. Based on 45nm Hi-k next-generation Intel architecture, Atom processors have power management features that make them ideal for thermally constrained and fanless embedded military applications, or ultra low power devices such as man-wearable field computers.

Computer-on-Modules (COMs) are ideal for x86 implementations and have gained significant ground here, largely due to the amount of performance that can be packed into a small form factor has increased so dramatically with the arrival of Intel's 45nm architecture. Developed specifically to address very compact, performance hungry and thermally-constrained embedded applications, 45nm technology achieves fast performance (with clock speeds between 1.1 GHz and 1.6 GHz) in a sub 5 watt thermal power envelope. Since it is power-optimized on the front side bus (of up to 533MHz), it enables faster data transfer.

For complex applications such as unmanned vehicles, training simulators and portable tactical communications devices, military designers may consider COMs such as ETX® or COM Express™ including the Basic (example: Kontron ETXexpress-PC) and Extended form factors in addition to compatible compact modules such as microETXexpress or nanoETXexpress.

Small, ultra-mobile devices are making the most of Intel's high-performance, energy-efficient solutions to enable soldiers to access information anytime, anywhere and improve their situational awareness. The reduced size and weight of these devices gives soldiers the freedom and flexibility to easily communicate with others.

Performance Considerations

Traditionally military systems have had an insatiable appetite for performance, and the latest Intel processor technology readily satisfies that need. Military data centers, ground vehicles, field logistics depots, mobile soldiers, wireless communications centers, digital military bases, field command centers, radar ground stations, unmanned vehicles, and sea, air and ground data centers all benefit from the power, performance, longevity, ruggedness and cost advantages of Intel x86 products.

For example, Kontron's latest generation of 6U CompactPCI products, such as the CP6016, incorporate Intel® Core™2 Duo processors with 45nm technology. This increases data throughput significantly from earlier processor generations – and the boards have up to 25 percent faster core speeds (2.53 GHz), 50 percent more L2 cache (6MB) and a 60 percent faster FSB (1066 MHz) with similar energy consumption. The end result for military designers is that CompactPCI can boost performance in a standards-based, multi-core platform that is able to meet highly demanding signal and data processing requirements, an ideal fit for applications on board submarines, naval ships, aircraft systems and ground vehicles.

Today's UAVs benefit as well, ranging widely in size, weight and function from a full-sized Predator aircraft, to a portable surveillance drone that can be carried in a soldier's field pack and deployed as an advance guard. In these instances, multi-core processing helps combat issues of power consumption and heat dissipation resulting from the use of serial switched fabrics, as well as the integration of multiple integrated systems and platforms.

Longevity & Availability

With more than 25 years on the embedded landscape, the VMEbus architecture has proven it is a strong platform for radar, sonar, image computing, data control, and electronic warfare applications in ships, aircraft and ground vehicles. It's also one of the strongest areas for migration to x86. Due to their rugged nature and proven design, systems based on VMEbus technology continue to be a viable choice for high availability military applications. Designers using x86 are seeing Kontron PENTXM2 boards combine all the well-known rugged benefits of VME with the latest processing power of 2 x Intel® dual-core processors. As a result, each of the Kontron VME boards provides rugged, high availability server grade performance for applications with extremely high demands on data throughput.

These rugged Intel-based products represent a significant contrast to the consumer arena, where Intel brings new chipsets to market several times a year with previous versions quickly becoming superseded by subsequent versions and unavailable shortly thereafter. To accommodate the needs of Tier 1 defense suppliers that typically must supply their customer – the U.S. government

designers rely on the standards that describe the different levels – standard commercial grade, extended temperature grade, a rugged-air and rugged conduction cool grade, and the most rigorous grade has to withstand 40Gs of shock on three axis – to determine their design path. Rugged design may be incorporated at the board level, the system level or on the overall design, and may mean operation without any airflow from -40 to +85° Celsius.

As a highly rugged example, the emerging VPX platform is ideal for data-intensive UAV applications where greater performance and I/O bandwidth are needed. Kontron in fact has a special design initiative allowing an easy migration path from VME to VPX for many of its product lines. VPX connectors handle high frequency signals and support 10GEth, PCIe fabric, SATA II – and, as mil/aero programs become increasingly net-centric, having several processors computing data expedites the speed of the system. Multiple cores running on one board ultimately saves space as well. Based on the latest dual-core 1.5 GHz Intel® Core™2 Duo processor with Low Voltage options, the Kontron VX3020 VPX CPU board offers high-end processing performance to meet a wide range of demanding signal and data processing requirements. The Kontron VX3020 easily executes demanding PCI-based applications with support for high-performance PCI-based software as well as PCI-Express, configurable either as x4 or quad x1 over the backplane.

Cost Considerations

Cost always plays a role in the selection of components. Nowhere is that more true than in military embedded systems. In terms of dollar amount, Intel Architecture is on par cost-wise with competing technologies, such as the PowerPC Architecture. Beyond monetary outlay, Intel Architecture brings embedded design value in other ways with decreased power consumption, increased performance, long lifecycle and superior ruggedness. These traits combined with Intel's reputation and commitment to the embedded market position Intel and key suppliers such as Kontron as valuable resources for leading-edge products and engineering know-how.

Making the Transition to Intel Architecture

Designers may have a significant challenge when tasked to change or improve the capabilities of an existing system, build a brand new system or deal with an End of Life notice from a supplier. By selecting Intel Architecture, these seemingly daunting tasks are readily handled.

With either new or migrating designs, the diverse design requirements of the modern military will continue to see benefits from Intel's performance-per-watt increases and the ease of software integration allowed by Intel Architectures. And with Intel's stated embedded roadmap moving from a three-chip solution all the way down to a single-chip solution (even in the not-too-distant future), engineers can anticipate an increasing number of design options with Intel Architecture. With low power consumption, high performance, long lifecycle and superior ruggedness the Intel x86 processors are a sound investment on a variety of popular military platforms. And by leveraging the extensive manufacturer-designer relationship in the migration process – tapping Kontron's depth of design knowledge as a critical resource – designers have significant expertise available to support both software and hardware migration requirements.

About Kontron

Kontron designs and manufactures embedded and communications standards-based, rugged COTS and custom solutions for OEMs, systems integrators, and application providers in a variety of markets.

Kontron engineering and manufacturing facilities, located throughout Europe, North America, and Asia-Pacific, work together with streamlined global sales and support services to help customers reduce their time-to-market and gain a competitive advantage. Kontron's diverse product portfolio includes: boards & mezzanines, Computer-on-Modules, HMIs & displays, systems & platforms, and rugged & custom capabilities.

Kontron is a Premier member of the Intel® Embedded Alliance and has been a VDC Platinum Vendor for Embedded Computer Boards 5 years running. Kontron is listed on the German TecDAX stock exchange under the symbol "KBC". For more information, please visit: **www.kontron.com**

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