Highly Parallel HPEC Platforms

Optimizing I/O Throughput for High Performance in Mil/Aero Applications

By Vincent Chuffart, Product Portfolio Manager, Avionics Transportation Defense, Kontron

Each generation of defense simulation and operational warfare systems increases demand for high-performance computing and I/O bandwidth in a compact, rugged system. Meeting those demands requires a matching generation upgrade in the high-performance embedded computing (HPEC) platforms that run these systems. However, obtaining the maximum performance from these platforms by providing the perfect balance of I/O and CPU power requires considerable expertise.

This article focuses on the latest version of the Kontron StarVX, a modular, scalable computer architecture featuring a rugged 3U-blade HPEC enclosure (Figure 1). We explore how its use of the new Kontron VX3058 3U blade delivers the highly sought balance of data throughput and processing power. We look at how integrated parallel workload management software simplifies workload consolidation. And we consider how the introduction of the first ruggedized server-class Intel® Xeon® processor product family designed for mobile platforms enables a substantial performance increase for radar, sonar, and many other digital signaling processing (DSP) applications.

The Challenges in Optimizing HPEC Performance

Military designers face an ever-growing need to provide platforms that can meet massive

Figure 1. The Kontron StarVX HPEC system brings enterprise server bandwidth and performance to military operations.
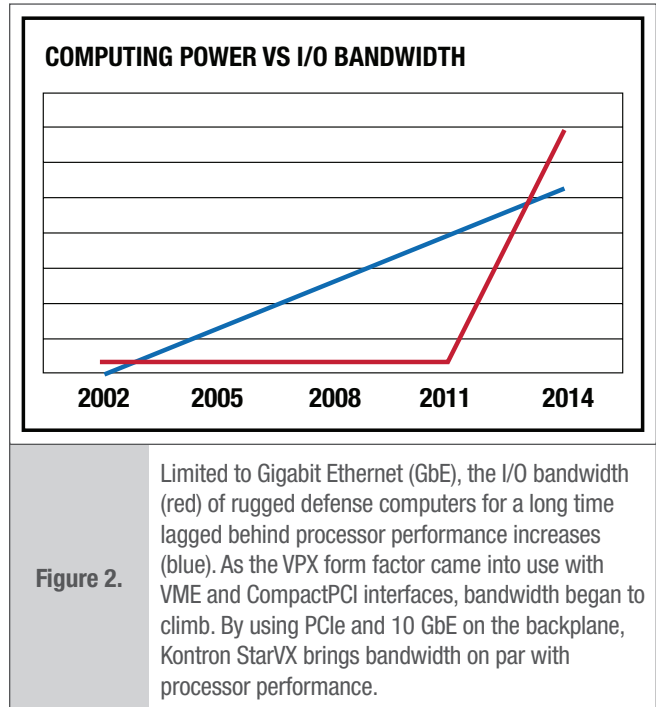
sensor data processing requirements and capably handle computationally intensive data while operating in harsh environments. From an engineering resource, budget, and deployment perspective, traditional proprietary systems no longer make sense. They cannot cost effectively keep up with processing and throughput demands.

New advances in embedded computing show great promise for enabling COTS designs that can match the sizeable speed, resolution and accuracy needs of today's mil/aero DSP applications. But familiar challenges crop up when trying to deliver optimum performance per dollar spent. In recent years, I/O bandwidth in rugged defense computers has failed to keep up with processor performance, creating bottlenecks and reliability issues (Figure 2). In addition, many applications have failed to take full advantage of the parallel processing and workload consolidation opportunities enabled by the multi-core processors in these systems.

An HPEC VPX System with an Innovative Throughput Solution

To close this performance gap, in 2013 Kontron integrated a PCI Express* (PCIe*) switch and a high-end L2/L3 Ethernet switch on a VPX blade – a platform known for high performance in harsh environments. The Kontron StarVx uses these blades to bring enterprise server performance and bandwidth – previously only achieved in IT data centers – to military operations. A small 3U footprint, combined with ruggedization, uniquely position the StarVX as an HPEC solution for military server consolidation.

As an OpenVPX-based and air- and conduction-cooled HPEC platform, StarVX offers extended operating temperatures to military systems used in harsh environments, including slot-based airflow temperature

COMPUTING POWER VS I/O BANDWIDTH

2002   2005   2008   2011   2014

Figure 2.	Limited to Gigabit Ethernet (GbE), the I/O bandwidth (red) of rugged defense computers for a long time lagged behind processor performance increases (blue). As the VPX form factor came into use with VME and CompactPCI interfaces, bandwidth began to climb. By using PCIe and 10 GbE on the backplane, Kontron StarVX brings bandwidth on par with processor performance.

control. The system can also hold payload boards in standby mode to meet low-energy surveillance requirements. In addition, the StarVX is shock, vibration, humidity, and altitude tested. To provide more capabilities within the 3U form factor, the StarVX's M.2 interface is available for storage use or integration of customized personality modules. An XMC slot and 2D graphics provide additional options, and the front I/O module is selectable for DVI/HDMI, Ethernet, or additional interface options.

The new Kontron VX3058 3U blade raises the Kontron StarVX HPEC System's performance to a higher level (Figure 3). The blade features two 10 GBASE-KR Ethernet ports and eight lanes of Gen3 PCIe to support reliable PCIe 3.0 and 10 Gigabit Ethernet (GbE) communications among all boards in the StarVX backplane across the full operational domain of a rugged computer design.

The use of PCIe 3.0 enables 40 GbE-equivalent data transfer rates with common TCP/IP protocols. Kontron's VXFabric* middleware enables this combination of PCIe 3.0 and TCP/IP by implementing the TCP/IP protocol over the PCIe infrastructure, boosting transmission bandwidth to nearly 40 GbE speeds.

With this bandwidth, the blade's 10 GbE switch and PCIe switch can be complemented with two single star data planes for 10 GbE and PCIe, respectively. Designers can use a unique Kontron VXFabric API with TCP/IP sockets to enable powerful, multi-CPU computing node architectures (Figure 4). There are no customized components or proprietary APIs to get in the way. The innovative VXFabric enables Kontron's HPEC platform to deliver high-speed socket-based communication between blades – the equivalent of exchanging a DVD-sized quantity of data in a second – with multiple switched fabric interconnects within the backplane.

By running TCP, a well-established transfer protocol, Kontron is able to minimize software impact during system development and enable the quick transfer of legacy applications to the new platform with little or no modification. Routing of the PCIe fabric is handled by Kontron's own optimized VPX PCIe 3.0 switch. This switch roughly doubles the per-lane throughput compared to PCIe 2.0 to provide a major performance boost.

Thanks to the VXFabric, the Kontron 3U VPX platform architecture provides up to 6 Gbps sustained bandwidth on the data plane through TCP/
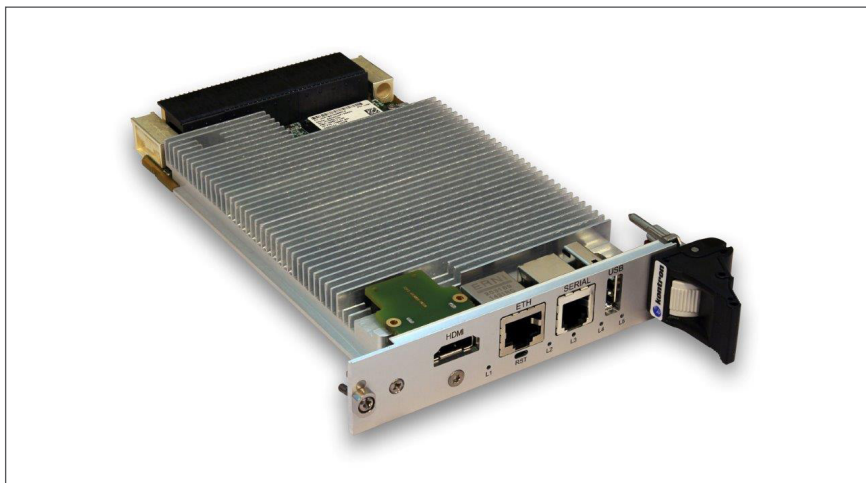

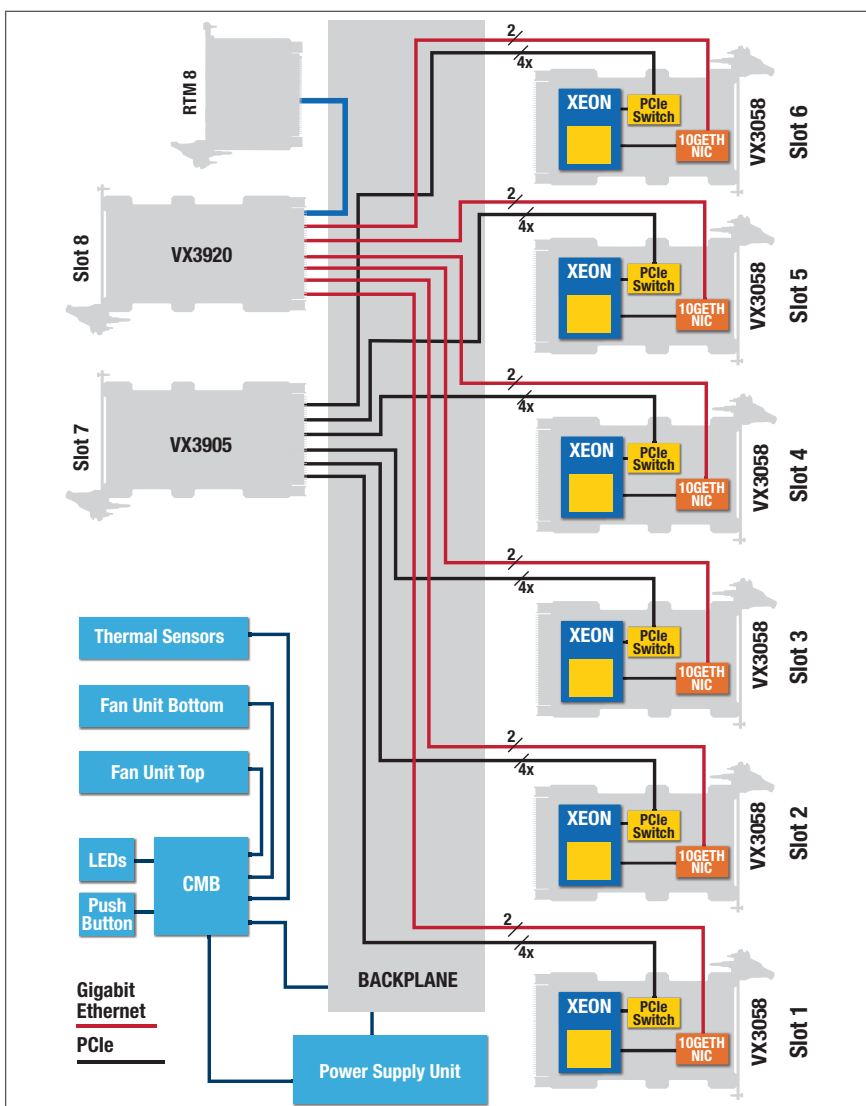| Figure 3. | The Kontron VX3058 3U blade integrates two 10 GBASE-KR Ethernet ports and eight lanes of PCIe 3. |

| Figure 4. | Built for bandwidth, the StarVX architecture includes a unique Kontron VXFabric API with TCP/IP sockets to enable powerful, multi-CPU computing node architectures. |

> # Designers can complete any design on mainstream IT servers and then deploy them unmodified on the StarVX.

IP, and 4 Gbps on the PCIe backplane. The result is an application-ready platform that delivers up to 10x more I/O data bandwidth than previously available ruggedized HPEC platforms – a performance increase that can enhance even existing unmodified TCP/IP-based applications. The VXFabric also addresses all fast and low-latency peer-to-peer inter-computer node communication within a chassis. VXFabric can deliver up to 4.2 Gbps in data throughput over PCI Express between VPX boards in a rack.

Optimizing Parallel Virtual Machine Execution

The ability to consolidate workloads on a single machine using parallel virtual machine (VM) execution is a real advantage to designers of solutions using HPEC systems. Kontron's StarVX 3U blade provides a modular baseline for building highly parallel rugged computers that run advanced military applications designed to take advantage of the extensive capital and operational efficiencies provided by isolated workloads configured to dynamically share common resources.

The blade includes integrated parallel workload management software, providing a compiler that simplifies design and cuts development time by automating much of the parallel sensor development and deployment software work. This software compiles for the complete StarVX system instead of just a single processor. It automatically builds optimized distributed code, taking care of the algorithm mapping, data organization, and data transfers necessary to deploy a given application on the StarVX architecture.

Through virtualization and this parallel workload management software, a single application design based on the StarVX can be easily optimized for parallel VM execution, as well as later adapted to hardware evolution needs such as CPU count, memory, form factor, and I/O availability. This helps military designers future-proof their solutions.

Tested to be Application-Ready

Kontron designed the StarVX to be completely application-ready by

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Silicon Motion Osprey Visual IoT Platform
the Intel® Quark™ SoC X1000 series with Ferri-eMMC & SM750 Graphics

Osprey Visual IoT platform is a product ready design kit for intelligent displays targeted at connected visual applications. Ideal for low power Industrial HMI, POS, Kiosk, signage, medical device, test instruments and dual display clients incorporating Intel® Quark™ SoC X1000 series 400MHz 32-bit x 86 processor into today's IoT connected systems.

Application:
- Digital signage
- Medical
- HMI / Factory
- POS / Kiosk
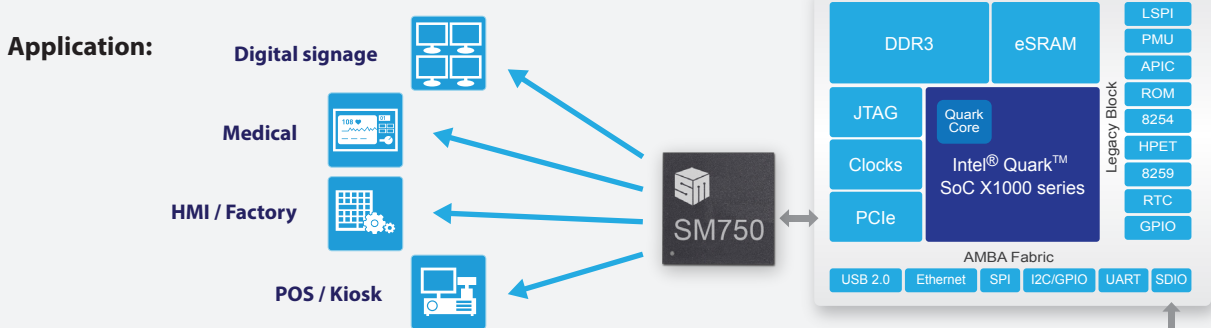
Osprey IoT Platform provides a rich set of standard I/O interfaces included in the Intel® Quark™ SoC such as Ethernet, USB Host, USB Client, UART, SPI, I2C and GPIO. Multiple display outputs are driven by Silicon Motion's SM750 and Ferri-eMMC provides the high performance system storage with robust data integrity, and compliance to industrial standard eMMC 4.5 specification.

SM750
- PCI-Express x 1 Architecture
- 16MB Integrated Video DDR Memory
- Low Power Consumption < 1.5W
- Supports single display up to 1920 x 1200 or dual display up to 1920 x 1080 (Full HD)

Ferri eMMC
- Industrial Standard : JEDEC / eMMC 4.5 with 100-ball BGA
- High-Efficiency Error Correction
- Advanced Global Wear Leveling
- Robust Data Protection

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fully testing the backplane and the processor, as well as integrating the necessary software that permits developers to more easily add their particular application technologies. The StarVX is available complete with Linux* distribution, diskless node support, parallel workload management software with integrated compilers, optimized fast Fourier transform (FFT) benchmark code samples, and a stress test application framework for benchmarking.

Since the StarVX is based entirely on IT technology such as Intel® processors, Linux, TCP/IP, and PCIe, designers can complete any design on mainstream IT servers and then deploy them unmodified on the StarVX. This is a big development advantage in enabling agile acquisition models, and also reduces obsolescence risk.

Customizing the StarVX is simple. Each design element is dedicated to a specific function: computing, switching, storage, cooling, and power supply. Each can be qualified to operate under a defined target environment.

For remote management, Kontron offers health- and power-management capabilities. Computer health management is available through Kontron VXControl*, an application that provides extensive status information, control, and monitoring at the board and subtrack level via a flexible SNMP or HTTP interface.

Rugged Server-Class Processor

To bring enterprise-class performance to field systems, Kontron now offers the StarVX with the new Intel® Xeon® processor D-1500 product family. These new members of the industry's most widely deployed data center processor microarchitecture deliver the advanced integration to meet size, weight, power, and cost (SWaP-C) criteria and provide an optimal engine for HPEC platforms.

The processor family packs the performance and advanced intelligence of Intel Xeon processors into an ultra-dense, lower power system-on-chip (SoC) – see Figure 5. The Intel® Xeon® processor D family is Intel's 3rd generation 64-bit SoC, and the first based on Intel Xeon processor technology. According to the SPEC CPU* 2006 benchmark, these 14 nm processors deliver up to 2.6x faster performance per node on parallel integer operations while providing up to 1.7x better performance per watt when compared to the Intel® Atom™ processor C2750 – a member of Intel's 2nd generation 64-bit SoC product family.

The Intel Xeon processor D-1500 family offers advanced server-class reliability, availability and serviceability (RAS) features, including support for error-correcting code (ECC) memory. To enhance security, Intel® Advanced Encryption Standard-New Instructions (Intel® AES-NI) provides integrated support for fast, low-overhead encryption, and Intel® Trusted Execution Technology (Intel® TXT) enables platform verification (through authenticated boot) for strong security with reduced performance impact. Ball grid array (BGA) mounting ruggedizes the Intel Xeon processor D-1500 family for military use.

The Intel Xeon processor D family's microarchitecture includes the Intel® Advanced Vector Extensions 2 (Intel® AVX2) instruction set for improved DSP performance. Built-in Intel® Virtualization Technology (Intel® VT) delivers near-native compute and I/O performance in virtualized network
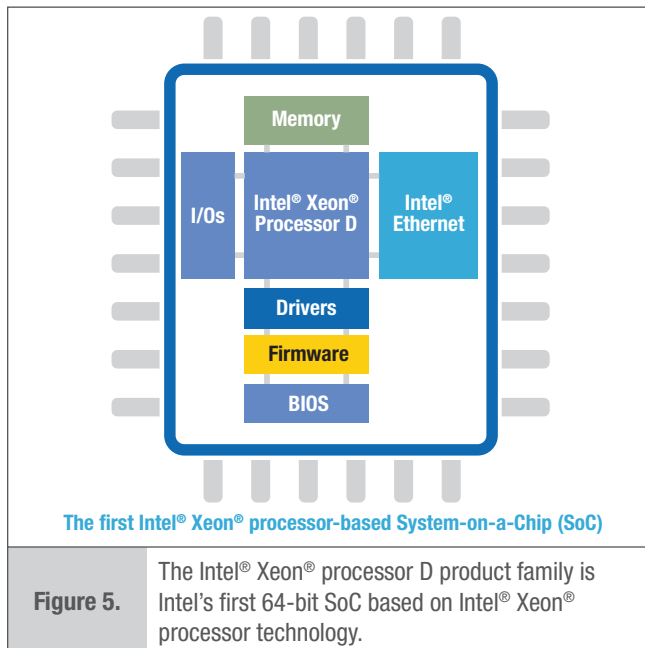

The first Intel® Xeon® processor-based System-on-a-Chip (SoC)

Figure 5.	The Intel® Xeon® processor D product family is Intel's first 64-bit SoC based on Intel® Xeon® processor technology.

infrastructure. Currently available with four or eight cores and 128 GB of high speed DDR4 addressable memory, these SoCs include an integrated platform controller hub (PCH), two integrated 10 Gigabit Intel® Ethernet ports, and a thermal design point (TDP) of 45 W.

The eight-core version Intel® Xeon® processor D-1540 enables StarVX blades to support heavier computing payloads. Military field operations can confidently use StarVX equipped with this new processor to deploy data center features such as libraries, middleware, and other technologies optimized for rugged application conditions.

Deploy a Rugged Application-ready HPEC System

As an HPEC system for mobile military deployment, the Kontron StarVX and VX3058 3U blades based on the new Intel Xeon processor D-1540, provide a particularly rugged, ready-for-action solution. Their ability to provide the right balance of throughput and high-performance computing ensures troops will have the information they need when they need it. Equally important, the features they provide military designers enable agile acquisition models for putting new solutions in the field faster.

For information on the Kontron StarVX, see intel.com/SD-kontron-StarVX; for more on the Kontron VX3058 3U, see intel.com/SD-Kontron-VX30583U.

For more on performance and bandwidth in mil/aero, see intel.com/embedded-milaero.

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