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SPECIAL FEATURE

Seven Technology Trends Driving Military Design Choices

To keep its technological edge, the defense industry must continue to leverage the best technologies grown from the consumer and commercial computing realms. Seven of these trends will dominate this year.

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Today's military embedded systems have an endless appetite for greater integration, more autonomous operation, faster connectivity and increased computing muscle. To achieve that system developers are leveraging advances along many technology fronts such as FPGAs, optical interconnects and server-class HPEC architectures. Gone new are the days when "new" technologies like switched fabrics, multi-core processors and box-level systems are no longer hampered by a perception as being risky avenues to take. Acceptance for those advanced computing building blocks make them now integral to today's defense electronics landscape.

Leveraged from the vastly larger consumer and commercial markets, there are always new game-changing technology and technology trends ahead for the military industry. Not all of these make life easier. That's because advances always bring along complexities that require special design considerations. Moreover, when some technologies are adapted for defense use there are unique aspects that affect military systems more acutely. Based on an informal survey *COTS Journal* conducted with technology suppliers in the military embedded computing industry, the following seven technology trends-in no particular order of priority-are the most important to consider in the year ahead:

Small Form Factor Systems

FPGAs -Reconfigurable Computing

Optical Interconnects

HPEC

Security / Anti-tamper

OpenVPX

Cloud Computing

1. Small Form Factor Systems

Driven by a desire to reduce their costs, many primes are outsourcing more by looking to embedded computing suppliers to meet their system integration needs rather than build electronic subsystems in-house. Serving those needs small form factor rugged box systems have become a staple in today's military embedded computing market. Over the past couple years there's been little or no standardization on the format or I/O configurations between vendors these products. Efforts have been made to standardization on the mechanical format or I/O configuration. In recent years three VITA specification efforts have been in the works in the past year or more: VITA 73, VITA 74 and VITA 75. But those efforts have only achieved limited buy-in, and particular no few products or progress with the specifications.

Among the standards-based box-level systems VITA 74-now dubbed VNX-has seen the most activity over the past 12 months. The VNX specification leverages concepts from the VPX and OpenVPX standards as well as the VITA 57 FMC specification. VNX defines two standard modules (Figure 1). Each are 89 mm by 75 mm, but differ in thickness and the number of pins associated with each module. Meanwhile, non-standard rugged- box level systems is perhaps one of the most active design activities in the embedded computing industry. These solutions are edging out traditional backplane-centric slot card system architectures in many military platforms. This box-level system trend is dominating wherever size, weight and power (SWaP) is a priority concerns-especially in UAVs and military vehicle electronic systems.

Figure 1
The VNX (VITA 74)-based ROCK-3 family of systems features the integration of the Intel Atom E3845 processor series as well as support for Wind River’s safe and secure operating system.

2. FPGAs -Reconfigurable Computing

There's no doubt that for military system designs FPGAs are the main engine for digital signal processing. The kind of signal processing functionality on today's FPGA chips are ideally suited to the kind of system-oriented DSP functions used in defense. And signal processing capabilities of FPGAs continue to climb satisfying those applications for whom an appetite for ever more processing muscle is endless. Today FPGAs have even become complete systems on a chip. The high-end lines of the major FPGA vendors have general-purpose CPU cores on them. And the military is hungry to use FPGAs to fill processing roles. Devices like the Xilinx Virtex-6 and -7 and the Altera Stratix IV and V are examples that have redefined an FPGA as a complete processing engine in its own right. And newer FPGA families like Xilinx's Kintex 7 and Altera's Arria 10 FPGAs are also showing up on embedded board-level products.

Illustrating the kind of scale to which FPGAs are used in the military, a couple years ago Lockheed Martin was awarded a an Air Force contract modification of over $104 million to procure and deliver of over 80,000 Xilinx FPGAs required for building Joint Strike Fighter aircraft. FPGAs are used in several of the F-35 (JSF)'s systems including radar, comms and navigation systems (Figure 2).

Figure 2
Several critical systems of the F-35 fighter aircraft use FPGA technology including its radar, comms and navigation systems.

3. Optical Interconnects

Discussed in theory in the embedded industry for decades, optical backplane technologies have been seemingly "waiting in the wings" forever. But demand for high-bandwidth interconnects and the likely widespread adoption of optical backplanes in the commercial market, are both factors moving the idea toward reality. Last year products and standards for this technology finally emerged driven by demands for even faster interconnect speeds. Optical links will boost data rates, improve signal integrity and security, and greatly extend distance between system components. In contrast copper cables suffer signal loss-a serious limitation for higher frequency signals and longer cable lengths. Across a span of 100 meters, optical cables can sustain data rates up to 100 times higher than copper cable.

The VITA 66 Fiber Optic Interconnect group developed a set of standards that bridge optical connections directly through the VPX backplane connector. The first three are variants for 3U and 6U systems and are based on MT, ARINC 801 Termini, and Mini-Expanded Beam optical connector technology, respectively. A recent product example is Pentek's Model 5973-312 3U VPX FlexorSet board. It incorporates the emerging VITA 66.4 standard for half size MT optical interconnect, providing 12 optical duplex lanes to the backplane.

4. High Performance Embedded Computing

While you'll get no disagreement in the industry about High Performance Embedded Computing (HPEC) being an important trend, there are widely different views on just what defines HPEC. Some says it's about highly dense arrays of GPGPUs while for other it's about accomplishing data-center level of computing with the use of server-class Xeon processors and all their support electronics. Still others insist that an element of computing virtualization is needed. A good broad definition is this: HPEC is leveraging technologies like VPX and rackmounted PCI Express to provide massive processing power for compute-intensive systems. Such systems strive to embed cutting-edge levels of throughput and processing into space-constrained systems handling more than a teraflop of data.

Some say there's an even further stake that software emphasis means to HPEC system development. If the computer architecture of an HPEC matches standard data center servers more exactly, they can take advantage of the same software model used by those servers. In other words, when an embedded system uses all the common components that standard servers use---Intel CPUs, GPUs from NVIDA (or Intel) and all the I/O devices that those server companies support, suddenly you can use the drivers, operating systems, libraries and tools that are available for running on any standard Intel-processor white box server to run your embedded application. Dynatem for example took that philosophy when developing its BoldHPC system. The system can contain one or two ACPU-20 blades of which includes 1 or 2 Intel E5 v2 processors, up to two NVIDIA Kepler processors (or Intel Phi's) and optional Altera Stratix FPGA Each blade can provide 3.3 Teraflops/s with an energy efficiency greater than 3.15 Gflops per Watt.

5. Security / Anti-tamper

A trend that continues to grow in importance is that of embedded security and encryption functionality into systems. It's a particularly challenging area because the demand for expertise is high while the costs of doing customized designs are a real burden. Problem is that support for anti-tamper capability or Differential Power Analysis (DPA) attack prevention aren't something that consumer chip makers are motivated to add to processors and memory chips. There have been advances in FPGAs and SoC offerings along these lines however. And embedded board vendors have started to take advantage of those.

Microsemi for example offers its SmartFusion2 system-on-chip (SoC) FPGA that's designed to address fundamental requirements for advanced security, high reliability and low power. SmartFusion2 incorporates

Differential Power Analysis (DPA) countermeasures that Microsemi has employed through a license from Cryptography Research Inc. (CRI). DPA is a class of attacks discovered by researchers at Cryptography Research.

DPA is able to extract secret keys and compromise the security of semiconductors and tamper-resistant devices by analyzing their power consumption. Extreme Engineering recently announced the 3U OpenVPX XPedite7572 with a 5th Gen Intel Core i7 (formerly Broadwell-H) processor and XPedite7672 with the Intel Xeon D processor (Figure 3). Both small form factor 3U VPX cards incorporate the Microsemi SmartFusion2 SoC as its root of trust. As implemented on these SBCs, the power-on control and boot path is entirely controlled and monitored by the SmartFusion2 to provide authentication and detection against many types of attacks.

Figure 3
The XPedite7672 integrates a SmartFusion2 security SoC for hosting custom functions to protect data from being modified or observed.

6. OpenVPX

OpenVPX seems to be headed for a busy phase in the upcoming year. Its full potential was probably inhibited in the past couple years because of defense budget cuts and the associated lack of many "new start" military programs. In terms of design wins, there's been a dip in publically announced VPX contract wins in the past couple years, but vendors say they're happening. Today OpenVPX has emerged as the natural choice of slot-card open architecture high-bandwidth, data-intensive military applications. Feeding those demands are a constantly growing ecosystem of vendors and product choices feeds this strong position VPX now claims. Over the past year there's been a lot of standards and interoperability activity around OpenVPX. At the same time, a tidal wave of new generation OpenVPX products, maintaining its place as one of the most active product category in our market in terms of new product releases.

7. Cloud Computing

Clearly the "Internet of Things" phenomenon has captured the commercial and consumer sectors by storm particularly in the past 18 months or so. For its part the military has long been interested in perfecting ways to move data captured from a multitude of sensors and collecting it on a virtualized "cloud" network where it can be used from any remote location. Instead of "IoT' the military has called that "Net-Centric" operations, but it really overlaps quite directly to what an IoT implementation is.

There are number of challenges unique to the defense market when it comes to cloud computing. First, each military force has its own infrastructure, both for connectivity and for the back office systems. Meanwhile the sheer complexity and high cost of defense systems means these systems must remain in service for many years. Those long system lifespans creates operational challenges for enhancing their capability and attaching them to the combat cloud. How would you share data between a stealth UAV and a legacy F-16 aircraft, or between the UAV and ground forces? For its part, Wind River says the solution lies in making use of multi-core silicon and virtualization. By separating legacy and new environments on separate cores and networks to it's possible to allow diverse systems to connect without slowing one another down. Operating systems that let enable such virtualization to happen seamlessly are a key part of that solution.

A Rich Variety of Innovators

The year ahead looks to be an exciting one as military system developers wrestle with these and other leading-edge technology trends. Fortunately, the technology suppliers that comprise our military embedded computing industry continue to develop leadership products that serve in line with all of these trends. And as prime contractors face the twin challenges of shrinking engineering staffs and tight budget constraints, they will need to rely of the expertise and products provide by our industry. With all that in mind, 2016 should shape up to be an interesting year.

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