Next-Gen Processor Technology Redefines Compute Density

The trend toward net-centric warfare and moving more data to the battlefield "edge"countinues. That's driving demand for highly integrated compute technologies such as the latest Intel Core i7 processor and 3U VPX.

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The demands of today's advanced military applications require system architects to constantly push the design envelope. These demands are coming from multiple fronts. The military is facing new enemies, which necessitate new war fighting strategies. The military is also facing new threats, such as IEDs, which necessitate new defensive and offensive techniques to keep soldiers out of harm's way. Unmanned vehicles and machines are increasingly being used not only to perform dangerous missions but also for surveillance and reconnaissance.

There is a continuing trend toward network-centric warfare and moving more data to the "edge," that is, to the soldiers on the battlefield to give them more accurate real-time data. To meet the needs of these new demands, systems must be smaller, lighter and faster-more processing power and bandwidth while at the same time reducing total footprint. Two technologies that together are meeting these demands by redefining compute density are the Intel Core i7 processor and 3U VPX.

Figure 1

Many deployed C4ISR systems have to be packaged in conduction-cooled ATR enclosures. The VPX (VITA 46) and OpenVPX (VITA 65) specifications support the design of conduction-cooled boards and systems like this one.

To address these new warfare demands, the trend has been to move more processing into the field using small deployed systems. Military applications span the range of the computing spectrum, but the type of applications these small, deployed high-performance systems satisfy can be classified as C4ISR (Command, Control, Compute, Communications, Intelligence, Surveillance, Reconnaissance). Even within C4ISR there is a wide range of applications, each having unique requirements. However, many deployed C4ISR applications share some common attributes. They are typically very compute intensive with high communication bandwidth requirements, they are deployed in harsh environments, and they

Figure 2

For large, high-power systems, air-cooled 6U VPX makes a lot of sense in rack mounted systems for an EP-3 aircraft. The EP-3 aircraft is used for electronic intelligence (ELINT).

have Size, Weight and Power (SWaP) constraints.

C4ISR Apps Push the Envelope

Representative C4ISR applications that have these common attributes are Software Defined Radio, radar processing, threat detection and avoidance systems, mine detection, and target recognition and verification, to name a few. Systems in unmanned vehicles also share these common attributes. A number of ISR systems are being deployed in UAVs and that trend is likely to continue as more unmanned air, sea and ground vehicles move into operation.

This trend to smaller, lighter, faster systems would not be possible without some important technology advances. There are three technology advances in particular that have supported this trend for deployed C4ISR systems. First, switched serial fabric technology has matured to the point where it is an accepted interconnect technology in embedded systems and, in fact, necessary to meet the communications bandwidth requirements in these systems. Fabrics like RapidIO and PCI Express provide multi-gigabyte pipes to move data through a system's data plane while Gigabit Ethernet can be utilized for the control plane communication.

The second advance is processor performance. Processors keep getting faster, but until recently higher performance was equated with higher power consumption to the point where higher-end processors could not be used in many SWaP-constrained applications. With the introduction of processors like the Intel Core i7 processor this has changed. The Intel Core i7 processor significantly increases the performance per watt over previous generations. Increased processor performance is enabling system integrators to deliver capabilities in deployed C4ISR systems that were not possible previously.

The third technology advance is increased device integration. With every generation of processors, more devices are integrated into a one or two chip solution such as memory controllers, PCIe, Gigabit Ethernet, graphics and USB. The drive to integrate more devices into a single chip provides tremendous space savings in systems where board real estate is at a premium.

Multicore CPU Meets Mil Needs

The latest processor from Intel delivers all the technology advances that are driving the trend to smaller, lighter, faster systems. The Intel Core i7 mobile dual-core processor is Intel's latest high-performance processor targeted for the laptop industry. Intel's Embedded Group has acquired this component and enhanced it for the embedded market by incorporating Error Correcting Code (ECC) into the integrated memory controller. Memory with ECC support is a requirement for most military programs as it improves reliability by allowing single-bit memory errors to be corrected and dual-bit memory errors to be detected. Intel's Embedded Group has also extended the standard product life cycle to meet military program requirements.

With the Intel Core i7 mobile processor, Intel has embraced a system-on-a-chip (SoC) design philosophy. This CPU removes the need for a northbridge by integrating a DDR3 memory controller, graphics core and x16 PCI Express interface. By removing the need for a Front Side Bus (FSB) to communicate with these high-performance interfaces, I/O and memory bandwidth are increased significantly. In addition to increasing performance, the SoC approach frees up significant board real estate. While Intel has offered integrated features in the past with their ultra-low-power component line, this is the first case where a high-performance processor and matching high-performance peripherals have been coupled into a single package.

A southbridge companion chip is still present and provides access to additional interfaces including SATA, USB, PCI and additional PCI Express. For applications requiring graphics, such as in-vehicle training systems, DVI graphics is integrated into the processor and southbridge. Integrating DVI graphics eliminates the need for an additional graphics card to lower the SWaP of the system in the vehicle.

In addition to integrating peripheral controllers, Intel has also refreshed the processor's microarchitecture and fabrication process. The performance enhancements of the updated microarchitecture significantly increase floating point and integer capability. Military system developers who currently use the Intel Core 2 Duo processor will see a sizeable performance increase at the same core frequency. The fabrication process improvements allow the core to be run at a lower voltage level, producing a higher performance per watt over previous generations. With the Intel Core i7 processor, Intel has both increased performance while decreasing power consumption. The level of device integration, support for high-speed serial fabrics, and performance per watt make the Intel Core i7 processor particularly well suited for deployed C4ISR applications with size and power constraints.

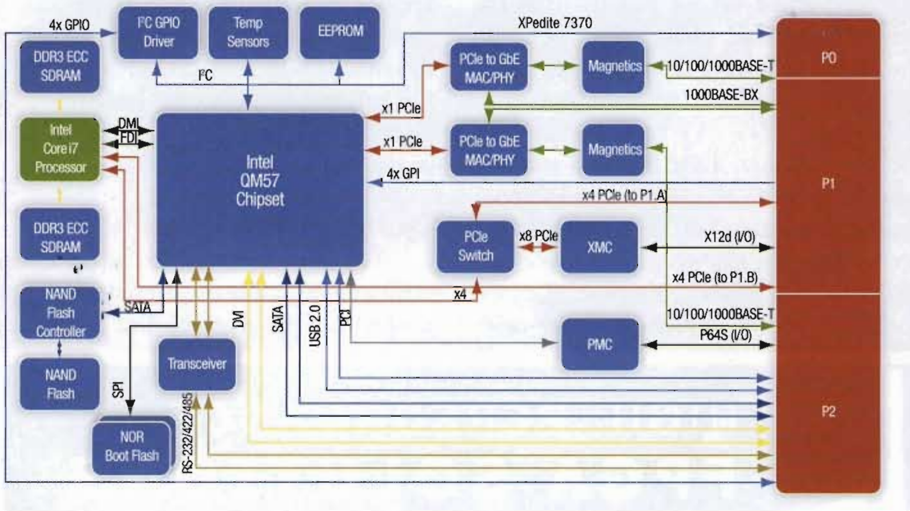

Figure 3

The 2.53 GHz Intel Core i7 processor based XPedite7370 3U VPX SBC will dissipate in the range of 25W to 30W. It offers 4 Gbytes of ECC DDR3 memory, integrated DVI graphics, SATA, USB, PCI Express for the VPX data plane, and Gigabit Ethernet for the VPX control plane.

OpenVPX Supports Next-Gen Needs

As mentioned earlier, deployed C4ISR applications are very compute intensive with high communication bandwidth requirements, they are deployed in harsh environments, and they have SWaP constraints. These systems need to be packaged in such a way that they can withstand the harsh environmental factors such a heat, cold, dust, shock, vibration, EMI and fog. Because of the environmental and SWaP constraints, many deployed C4ISR systems have to be packaged in conduction-cooled ATR enclosures (Figure 1). The VPX (VITA 46) and OpenVPX (VITA 65) specifications support the design of conduction-cooled boards and systems with VPX being the platform of choice for many deployed C4ISR applications.

The advantage of designing a system around the VPX and OpenVPX specifications is that they are accepted standards that support the development of board and system-level components. Board and system-level interfaces and integration issues have been addressed by the standards to provide compatibility and interoperability between boards and system-level components. When contemplating a new design, system designers have the assurance that there is an established ecosystem of VPX building blocks available from multiple embedded computing vendors including SBCs, processing modules, I/O, storage, backplanes, power supplies and enclosures. System integrators can also develop their own VPX boards and system components to integrate with commercial embedded computing components.

VPX supports both 6U and 3U form factors. For large, high-power systems, air-cooled 6U VPX makes a lot of sense, for instance, for a rack mounted system in an AWACS or EP-3 aircraft (Figure 2). But because of the SWaP and environmental constraints of many deployed C4ISR applications, large, air-cooled systems are not an option. For many deployed C4ISR applications, conduction cooling is the only practical choice, and in these instances conduction-cooled 3U VPX is often the right choice. 3U boards have less surface area than 6U boards, which makes 3U boards inherently more robust in terms of shock and vibration.

Reducing Board Count

With the increased level of integration and performance of computer technology, as evidenced by the Intel Core i7 processor, an application that in the past required a rack of 6U boards can now be implemented with a small number of 3U boards. There is a crossover point where more functional density can be achieved by using 6U boards, however, a large number of today's deployed C4ISR systems only need a small number of 3U boards-three to six-and don't reach that crossover point. If the functionality can be accomplished with a small number of 3U boards-such as less than six-it is intuitive that a system built with 3U boards can fit in a smaller space than a system built using 6U boards. Basing a system design on 3U boards also allows for a more modular design.

Cooling is possibly the most important aspect of determining whether to utilize a 3U or 6U form factor for a conduction-cooled, SWaP-constrained design. More functionality can be packed onto a 6U board, however, both 3U and

6U conduction-cooled boards have the same amount of surface area between the wedge locks and the side walls of the chassis from which to transfer heat off of the board.

Even though a 6U board is roughly twice the size of a 3U board, any additional heat it produces has to be transferred across the same heat transfer surface area to the chassis. Without employing exotic cooling methods, which in many cases are not practical, it is not be possible to cool high-powered 6U boards using traditional conduction-cooled approaches. For this reason alone, 3U boards are the better choice for many for conduction-cooled applications.

Tackling SWaP Issues

To minimize SWaP, system designers must maximize the functional density per watt within the given cooling limitations of their system. Traditional conduction-cooling technology can cool up to about 35W per slot. An Intel Core i7 processor-based 3U VPX SBC will dissipate in the range of 25W to 30W. From a thermal standpoint, this class of SBC is perfectly matched with the cooling capabilities of conduction cooling.

By choosing this type of SBC, system designers can maximize the functional density of their systems and thereby achieve the maximum performance in the smallest space. The XPedite7370 3U VPX SBC from Extreme Engineering Solutions (X-ES) (Figure 3), with a processor running at 2.53 GHz, 4 Gbytes of ECC DDR3 memory, integrated DVI graphics, SATA, USB, PCI Express for the VPX data plane, and Gigabit Ethernet for the VPX control plane, is an example of the level of performance and functional density that is possible within this power budget in a 3U form factor.

The Intel Core i7 processor delivers the right features and performance to support compute-intensive deployed C4ISR applications. The form factor of choice for many of these deployed C4ISR applications is conduction-cooled 3U VPX. Combining these two technologies into standard 3U VPX SBCs maximizes functional density for compute-intensive applications. With the available 3U VPX and OpenVPX infrastructure, system integrators have the building blocks they need to develop smaller, lighter, faster systems for their military customers.

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