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Cutting Rack-Mounted Systems Down to Size

Cluster Computing In Space-Constrained Applications

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Today's embedded computing applications are far more sophisticated than those of the recent past. Industries such as medical imaging, homeland security and military defense call for rackmount systems that can run a growing number of complex software applications. In many of these industries the reliable and timely processing of information can mean the difference between life and death. These industries also require equipment that can squeeze into tightly constrained spaces and—in some cases—meet low weight requirements. Providing the needed compute capability inside this space and weight envelope is a considerable challenge.

In the medical imaging field, applications vary from simple single slice x-ray machines to three-dimensional, multi-image slice CAT scan machines. Although these applications have widely differing compute requirements, they share a need for increased image clarity. This is driving a quest for higher-performance rackmount systems. At the same time, the overall size of the imaging machines is shrinking.

In the area of homeland security, cryptography analysis is a key element in understanding what the bad guys are planning. Cryptography analysis systems must process an extraordinary amount of incoming data from a wide variety of sources. These systems require advanced software that can sort out the incoming data in order to allow intelligence specialists to focus on the most important information. To meet these needs, rackmount systems must provide scalable performance in relatively small enclosures.

Surveillance aircraft represents a small slice of the overall military defense market, but they illustrate many of the challenges facing the rackmount system designer. Surveillance aircraft provide location information and near-real-time situational analysis—a critical role in today's military, where information is as essential as firepower. Fulfilling this mission requires an enormous amount of computational horsepower.

A typical airplane may have seventy computer systems dedicated to different aspects of the surveillance mission. The computer systems must also be flexible enough to handle the multiple system configurations used in the aircraft. The computers must have a long service life and a stable system configuration to meet the aircraft's long deployment and refurbishment schedules. Military end users require the use of commercial off-the-shelf (COTS) technology whenever possible.

In this article we will use surveillance aircraft as an example of rackmount system design challenges. We will show how designers can meet these daunting challenges by using cluster computers, which group single board computers together in a common chassis. We will outline the features and benefits of a cluster computer that incorporates quad-core Intel® Architecture processors, Trenton's PCI Express® single board computers, and multi-segment, passive backplanes.

Chassis & Backplane Design

Weight and space are at a premium on a surveillance aircraft. Additional computer hardware has an exponential effect on the cost of operating the aircraft. In addition to increasing the fuel costs, extra equipment weight creates mission delays due to the need for more frequent mid-air refueling.

Trenton addressed both the space and weight issues by developing a shallow-depth chassis made out of lightweight aluminum. Figure 1 shows an expanded view of a typical Trenton Systems platform designed for use in a surveillance aircraft application.

Figure 1. By taking advantage of cluster computing, this lightweight 5U chassis can replace up to sixteen conventional 1U chassis.

The most common rackmount chassis used on the aircraft has a depth of 18” (45.72cm) and a 5U chassis height. Each system has a multi-segment PICMG® 1.3 backplane that enables multiple single board computers (SBCs) or system host boards (SHBs) to function in a single chassis. Other chassis design elements include individual SBC segment power control, quick access storage drives, corrosion resistant metal work, a high-performance cooling system and armored cable sleeves for vibration protection.

The backplane is often a frequently overlooked component of an embedded computing system, but it is an essential element of a high-performance embedded design. Today’s higher bandwidth card-to-card interfaces such as a PCI Express® (PCIe) demand robust backplane designs in order to maintain optimum system throughput. For this system, we used the four-segment Trenton BP4FS6890 backplane (Figure 2). This multi-segment PICMG 1.3 backplane is available in server-class or graphics-class configurations.

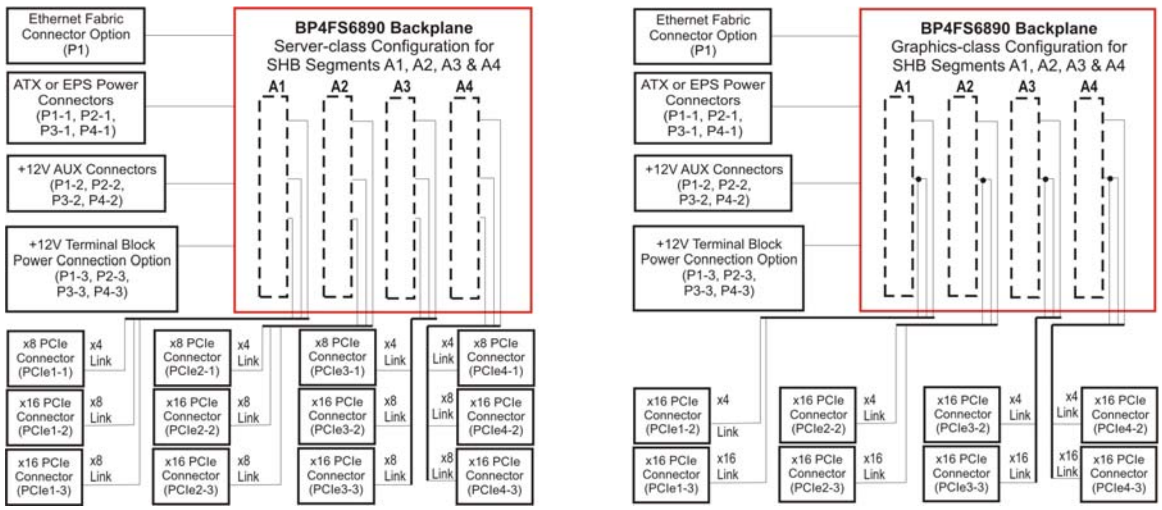

Figure 2. The Trenton BP4FS6890 backplane supports server-class (left) and graphics-class (right) configurations.

The PICMG 1.3 backplane supports one or more SHBs, as well as industry standard COTS option cards for functions including communications, video, sound, and data storage. This design allows designers to mix and match single board computer capabilities based on the needs of the application.

System Host Boards

Figure 3 shows the two types of Trenton SHBs used in surveillance aircraft: the Trenton TQ9 System Host Board and the Trenton MCXT System Host Board. Each SHB features quad-core processors with Intel® Virtualization Technology (Intel® VT).

Figure 3. The Trenton TQ9 (left) and Trenton MCXT (right) system host boards.

As noted above, up to four SHBs can be used in a single chassis. The SHBs can function together as a computer cluster, where all boards work together on the same application. Alternatively, each SHB in the chassis can act as a computer unto itself. Intel® Virtualization Technology (Intel® VT) takes this concept further by allowing a single SHB to run multiple independent operating systems and applications. The combination of the multi-SHB chassis and Intel® VT saves rack space by allowing a single chassis to run many independent applications.

A chassis with four dual-processor Trenton SHBs can run up to 32 different applications—one for each processor core in the chassis. This means that one 5U rackmount computer, with four dual-processor SHBs, can take the place of sixteen 1U dual processor motherboard systems. Using a single 5U enclosure instead of sixteen 1U enclosures reduces rack space by 19.25" (48.90cm)—a nearly 70% savings.

Remember that an aircraft can have up to seventy systems, so this space savings is repeated many times throughout the plane. The space savings supplied by the Trenton cluster computer solution also comes with a cumulative weight savings advantage because the solution requires fewer cables, enclosures and computer power supplies.

So far we have only briefly outlined the features of the system host boards. In the following sections we take a closer look at the technologies in the two SHBs used in this application, the Trenton TQ9 System Host Board and the Trenton MCXT System Host Board.

Trenton TQ9 System Host Board (SHB)

The TQ9 is a single-processor, graphics-class PICMG 1.3 system host board. Among other responsibilities, the TQ9 helps render information for analysis by intelligence specialists. As a graphics-class board, the TQ9 supports one x16 and one x4 PCIe electrical link. The x16 PCIe link is a common edge card connector interface on many high-end graphics cards. This link is useful for aircraft systems that require video or other high-performance graphics. The x4 PCIe link may be used on a backplane as four individual x1 PCIe links, giving designers an added degree of flexibility.

In this application, the TQ9 is configured with the Intel® Core™ 2 Quad Processor Q9400. This processor features a quad-core design, a 1333 MHz front side bus and Intel® Virtualization Technology. Virtualization enables multiple operating systems to run on the TQ9, which in turn allows the end user to run multiple applications on the same SHB. The TQ9 also comes equipped with the Intel® Q35 Express Chipset, which incorporates a 3D graphics accelerator.

Other TQ9 features include:

- Four DDR2-800 sockets supporting up to 8GB of system memory
- Four SATA II 300 interfaces with RAID support
- On-board audio and video support
- Eight USB 2.0 interfaces
- Support for an I/O expansion board, including an optional TPM 1.2 module

The Intel parts used in this design are long-life products supported by the Intel® Embedded and Communication Group. The long-life product support allows Trenton to meet the stability and longevity requirements of surveillance aircraft applications. Trenton designs in other extended life components to ensure that the completed systems meet and exceed the deployment cycle requirements for the aircraft.

Trenton MCXT System Host Board (SHB)

The MCXT is a dual-processor, server-class PICMG 1.3 system host board. This SHB supports one x4 and two x8 PCIe links down to the backplane. The MCXT is used to handle the heaviest loads of data and the most complex situational analysis software on the aircraft.

The MCXT configurations on the plane use the quad-core Intel® Xeon® Processor E5440 and the Intel® 5000P chipset. Both processors on the MCXT communicate directly to the chipset along independent, 1333 MHz front side busses. The chipset in turn features a four-channel DDR2-667 memory interface. As with the TQ9, this Trenton MCXT SHB configuration features long-life devices that support Intel® Virtualization Technology.

Other MCXT features include:

- Four DDR2-667 FB-DIMM sockets supporting up to 16GB of system memory
  (or eight sockets and 32GB of memory in the MCXT-E version)
- Six SATA II 300 interfaces with RAID support
- On-board SXGA video support
- Four USB 2.0 interfaces
- Support for a x4 PCI Express link expansion

Cluster Computing System Design – Summary & Conclusion

The design objectives for surveillance aircraft are challenging but are certainly not unique. Equipment space constraints also exist in medical imaging systems, cryptography analysis, telecom, industrial automation, and many other applications.

Trenton single board computers and multi-segment backplanes bring the same space and efficiency benefits seen in the surveillance aircraft to a wide variety of embedded computing applications. Many applications need to run different applications on a single platform, and single board computers and backplanes have long made this possible. This basic architecture design advantage is now coupled with the Intel® Virtualization Technology. This potent combination gives system designers the ability to leverage the benefit of cluster computing across a broad range of industry applications.

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