VITA 31.1: Extending VME via Ethernet switching

By Valerie Andrew

One easy way to add high-performance switched serial fabric data communications to VME systems is via the VITA 31.1 Ethernet architecture. Based upon the PICMG (PCI Industrial Computer Manufacturers Group) 2.16 CompactPCI packet switched backplane standard, VITA 31.1 adds an Ethernet data plane into legacy systems while relying on the tried-and-true VMEbus as the control plane.

The good news is that the VMEbus standard has been static for a long while, but the bad news is that users have also not seen any material increase in performance. A robust standard like VME finds itself designed into high-reliability and long-life programs, and maintaining legacy continuity by smooth upgrades is equally as important as adding performance. All the while the VMEbus stayed stable, many system designers had to look elsewhere for increased parallel bus performance and for alternate platforms that supported a network system architecture with faster throughput and enhanced connectivity configurations.

At last, one recent enhancement to VMEbus is the ANSI/VITA 1.5 2eSST extension that allows bus bandwidth to be increased to 320 MBps – a dramatic improvement over the original 40 to 80 MBps parallel bus speeds. Additionally, the new VITA 31.1 standard builds upon the PICMG 2.16 CompactPCI Packet Switched Backplane (cPSB) standard. This adds a high-speed switched fabric interconnect based upon Ethernet that can move data between VME cards in a backplane or system.

With these two new standards, VME32/VME64 can now coexist with a dual star network overlay via VITA 31.1 within a VMEbus backplane, along with ANSI/VITA 1.5 2eSST cards talking at 320 MBps. System designers can easily extend the original legacy VMEbus performance within the same system chassis. Existing technology, such as specific I/O schemes, can be maintained while migrating to the future without switching to a new bus standard; the usual retraining and logistics associated with a new technology can be avoided.

What is VITA 31.1?

Almost all new designs are requiring connections to legacy and new networks. In the military this is occurring in land, mobile, ship, and Homeland Security-based applications. Fabrics are being implemented in all vertical markets, including medical, telecom/datacom, transportation, data acquisition, and radar data processing – basically anywhere that Ethernet connectivity is required.

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VITA 31.1 is a fabric-based VMEbus environment that allows the implementation of an Ethernet fabric across a VMEbus backplane. Many defense companies who are traditional VME users have been evaluating and/or deploying CompactPCI PICMG 2.16 systems because they could not get an Ethernet fabric across a VME system, yet they wanted to maintain compatibility with their legacy hardware investments. This is why the VITA 31.1 working group was assembled: to study a better method of transferring large amounts of data between VME boards, with an emphasis on packet switching.

A quick solution that enabled VME users to maintain backward compatibility with legacy boards was to implement PICMG 2.16 Ethernet switched fabric on cPSB in a VME system. PICMG 2.16 implements Ethernet over the backplane using the CompactPCI J3/P3 connector. The P0/J0 connector on a VME64x backplane was matched to the PICMG 2.16 pinouts for J3/P3, and this solution was adopted by the working group. VITA 31.1 moved from a working group into an approved ANSI specification in 2003.

The Ethernet fabric is implemented through the VME P0 connector and becomes the *data plane* of the system. Here all nodes can communicate with each other at near wire speed. The traditional VME parallel bus is used as a control plane where global out-of-band control and setup operations can take place if required. Both single and dual star Ethernet networks are supported. The dual star topology can be used to eliminate single points of failure. If all inter-board communication is done over the network, then the VMEbus itself can be eliminated as a single point of failure.

The VITA 31.1 standard uses the same Ethernet fabric switches as those specified by PICMG 2.16. By leveraging the existing PICMG 2.16 technology, VITA 31.1 uses Ethernet switches already available in the market. VITA 31.1 enables the VME user to utilize existing VME64x technology and software while providing an effective means of providing point-to-point interconnections across the backplane. More importantly, VITA 31.1 utilizes existing Internet Protocol (IP) software to enhance time-to-market. The backplane is designed with that very backwards compatibility in mind, so the system can still take advantage of legacy VME products.

In a typical VITA 31.1 backplane, a maximum of two Ethernet fabric slots are provided. Two Ethernet ports represent an A and B network in a single node slot. All A ports are routed to the A switch and all B ports are routed to the B switch, realizing a single or dual star topology. The remaining slots (up to 19) are VME64x with the J0/P0 pinout routed the same way as the J3 in PICMG 2.16. Figure 1 shows a fully configured example VITA 31.1 system.

Why is Ethernet used?

Using Gigabit Ethernet as the data link layer for a fabric interconnect allows a low-cost physical implementation that supports significant data transport bandwidth. Ethernet also allows straightforward hot swap schemes since the physical connection does not require specific conditioning for removal. With widely available IP protocol stacks and HA software, users can build robust, fault-tolerant schemes using VMEbus blades as replaceable nodes, such as the dual star topology shown in Figure 2. In VITA 31.1

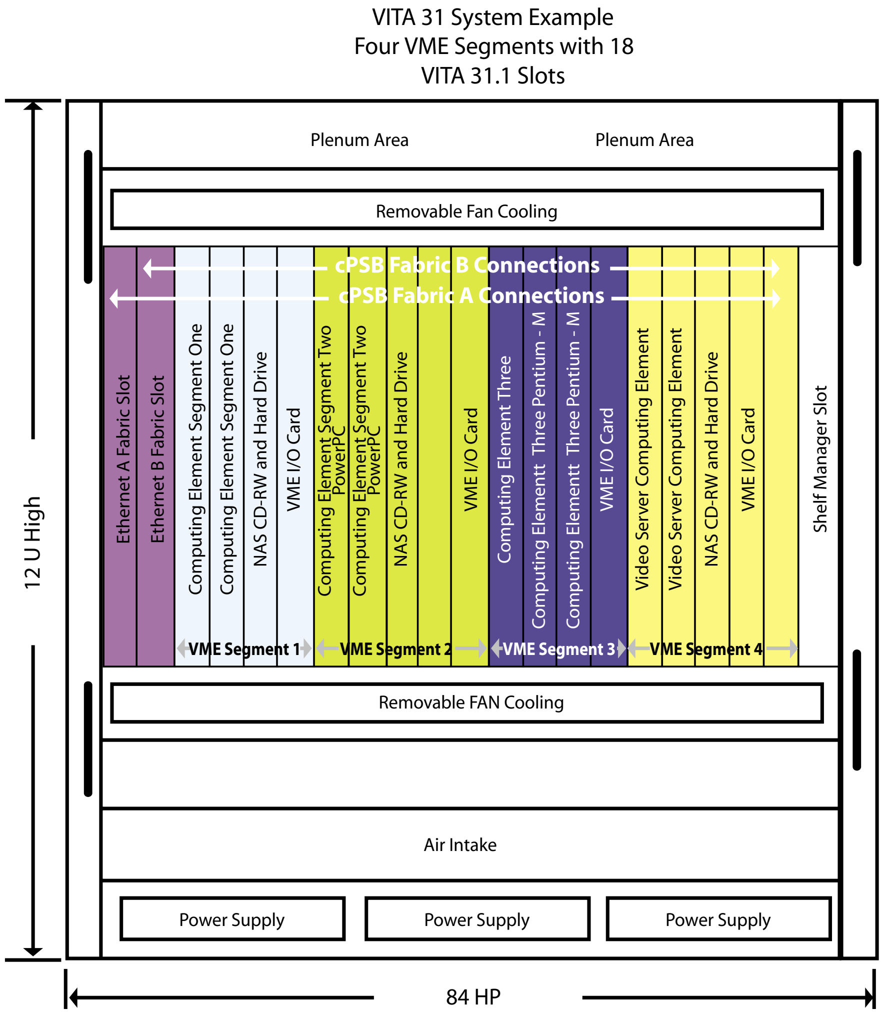

Figure 1

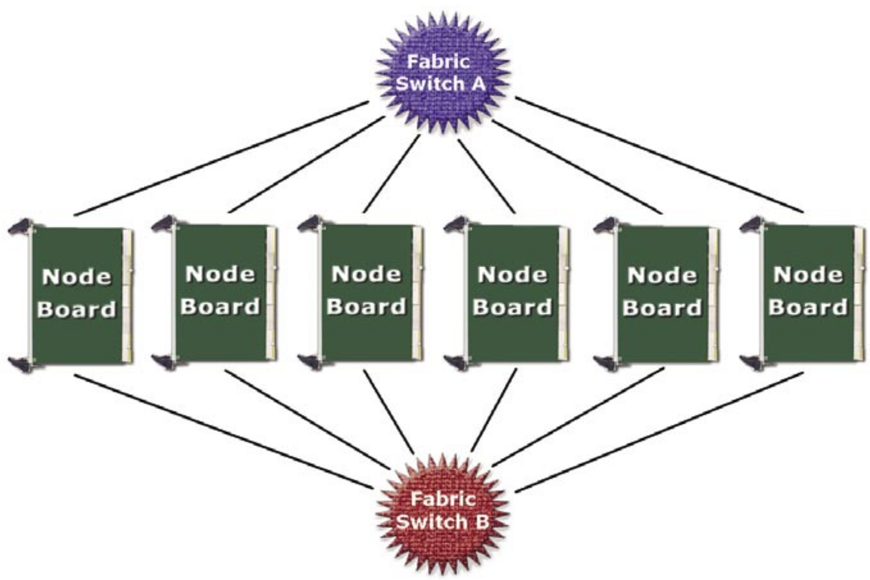

Figure 2

SIDEBAR

A brief review of VME

For over two decades, VMEbus has offered a standards-based parallel bus solution that has evolved to meet tough application demands. It scaled the clock and provided bus width extensions starting at 8 bit, then going to 16, 32, and then 64 bits. Bandwidths were typically up to 40 MBps for standard VME; VME64 increased that bandwidth to 80 MBps, then a theoretical 160 MBps was proposed with 2eVME. Recently, a tremendous jump in performance can be seen with the advent of 2eSST boards such as single board computers from Motorola and Thales Computer and PMC carriers from ACT/Technico and Interface Concept.

The increase in bus performance is achieved via the Tundra TSi148 bridge chip, which supports up to 320 MBps sustained rates. As bandwidth and clock rates increase, however, the parallel bus runs into issues with timing or skew, along with reflections. Signal alignment cannot easily be maintained at high clock rates, which is why switched fabrics based upon technologies such as Ethernet are so attractive to system designers. Additionally, VME systems don't have a convenient way to implement an Ethernet fabric across the bus.

systems, independent backplane subsections can be built that allow interslot subsystem connectivity via the parallel bus, while all slots in the backplane are connected via the embedded Ethernet fabric and switches. Here, redundancy and scalability can be considered as part of the system design.

Considering throughput, one can consider a single Gigabit Ethernet connection to represent the same point-to-point bandwidth as a typical VMEbus segment, or 40 MBps. This is scalable by the number of cards supporting Gigabit connections in the system; hence the system itself is scalable in performance, whereas before it was bound by the bandwidth of a single VMEbus interconnect.

If one were to implement a similar architecture the old-fashioned way, it would require two cables per node SBC and an external Ethernet switch or two. When using VITA 31.1, the cables are eliminated by the connections in the backplane. The switches themselves are also 6U by 160 mm cards plugged into the VME backplane, providing an environmentally superior form factor over a conventional box level design.

Serial fabrics' effect on designs

When designers are looking to connect systems together and make systems scalable, serial fabrics are being considered. The military using networked systems locally within platforms and globally between defense systems, and programs such as Future Combat Systems (FCS), has such requirements. Serial fabrics and cPSB-enabled components are making this task more straightforward by providing basic networked building blocks that provide enormous aggregate bandwidths. Consider, as an example, the network bandwidth of a typical layer 2/3 switch at 800 Mbps unblocked.

The serial fabric used in VITA 31.1 offers some of the following advantages:

- Point-to-point connection to the switch, which eliminates any single point of failure
- Low Voltage Differential Signaling (LVDS)
- Switching rate support up to 2 Gbps aggregate per slot, sustained

Best of all, these new serial fabric interconnects are available in an open architecture environment such as VME. They provide a forward path from multiple vendors, reducing the risk to the customer of being locked into a single supplier. The solution is also scalable, extending systems to communicate between multiple systems.

Why VITA 31.1?

When examining reasons for implementing VITA 31.1, it is natural to compare it to the standard on which it is based: PICMG 2.16. System designers have been using PICMG 2.16 since it allows for system scalability and provides an architecture for building highly available systems. The cPSB architecture eliminates single points of failure and supports redundancy. By allowing the VME form factor to be retained and adding a network interconnect without the use of cables, VITA 31.1 provides a seamless and scalable networked system architecture. Given that one's investment in VME can be preserved while gaining the advantages of the PICMG 2.16 standards, VITA 31.1 provides the system designer with an extensible design while retaining components based on open standards.

In addition to VITA 31.1, the VMEbus itself also implements *shelf management,* as called out in the VITA specification ANSI/VITA 38-2003 (IPMI System Management for VME), again leveraging a PICMG standard. System management solutions allow the user to monitor parameters within the systems such as temperature, fan speed, and power supply status. This can be useful as part of a Built-In Test (BIT) and monitoring capability.

Sample applications

Following are actual examples of applications using VITA 31.1-based systems.

The Mitre Corporation entered a vehicle named the Mitre Meteor in this year's Defense Advanced Research Projects Agency (DARPA) Grand Challenge and chose to design their vehicle control system using VITA 31.1 technology. Figure 3 (courtesy of DARPA) shows the Mitre Meteor Grand Challenge vehicle on its first desert trials. The Grand Challenge, created by DARPA, is a field test to accelerate the research and devel-

Figure 3

opment of autonomous ground vehicles that are intended to save lives on the battlefield. The test is a 140+-mile race across the Mojave Desert following a designated route over manmade obstacles. The second annual race occurred in October 2005.

In another application, a government research lab is using VITA 31.1 as a development platform to build a new radar image processing system for unmanned aerial vehicles. It is intended to replace earlier equipment, which had significantly higher costs. Ω

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