Launched in the early 1980s, VMEbus employs a 3, 6, or 9U pc board with a pin-and-socket-connector interface to the backplane to withstand harsh industrial applications. The developers of the VMEbus created it by combining Motorola’s VERSAbus electrical standard and the Eurocard mechanical form factor. Although VERSAbus has since faded away, VME became popular with designers because it was processor-independent, based on a reliable mechanical form factor, and released as a nonproprietary standard. The original standard, now called IEEE 1014, specifies a master-slave configuration with 40-Mbyte/sec asynchronous data transfers between boards based on a variable-speed handshaking protocol. A VME backplane can contain as many as 21 card slots with multiple master computer boards. Many VME boards that conform to this original specification are still in use today.

Although upgrades were inevitable, VME manufacturers agreed to maintain compatibility with legacy hardware to protect user investments. VME has undergone several upgrades to increase the shared-bus-data-transfer rate, but each allows older products to communicate at their original speed. VME64, which ANSI (American National Standards Institute) and VITA (VMEbus International Trade Association) approved in 1996 as ANSI/VITA 1.1, increased data rates to 80 MHz by doubling the path width to 64 bits. Another doubling of the data rate to 160 Mbytes/sec reduced the transfer protocol from a four-edge to a two-edge handshake. The 2eSST (two-edge source-synchronous-transfer) interconnect of ANSI/VITA 1.5 can transfer data across the VMEbus at 320 Mbytes/sec. Although these upgrades are compatible with earlier hardware, data transfers must occur at the slowest device rate.

In many applications, expected data rates exceed the limitations of any shared-bus system. In these high-speed applications, such as medical imaging and other signal-processing systems, designers have turned to auxiliary communications techniques to bypass the shared bus and transfer data directly between subsystems.
VME has a history of third-party add-ons that use point-to-point connections and external crossbar switches to send high-speed information around the bandwidth-limited VMEbus (Reference 1). These point-to-point-communications schemes multiply their basic bandwidth by allowing several transfers to occur simultaneously. These early, high-speed-communications channels were the forerunners of today's switched-fabric interconnects.

**FABRIC FEATURES**

The main benefit of a switched fabric is that each connection is a direct point-to-point datapath, thereby eliminating the multiple connections of a parallel-bus structure. Most switched-fabric specifications call for LVDS (low-voltage differential signaling) for maximum bandwidth between nodes. Another obvious benefit of serial connections is the reduced connector sizes due to the use of fewer signal lines. A typical switching fabric may use several stages of high-bandwidth switches to route transactions between a source and a target. A sophisticated switched-fabric system can also increase system availability by routing data around defective paths or nodes.

Switched-fabric technology has become popular with embedded-system designers; however, a clear favorite and market leader has yet to emerge. ConceptPCI and ATCA (Advanced Telecom Computing Architecture), two current board-level standards, do not call out the specific fabric technology for data transport. Instead, a series of subsidiary specifications defines backplane details for the various fabrics, such as Ethernet, InfiniBand, StarFabric, PCI Express, and RapidIO. To satisfy differing views within the industry, the VMEbus specification will also allow multiple fabric technologies at the risk of interoperability issues.

The VXS (VITA 41 Switched Serial Extensions) append fabric technology to the VMEbus and preserves compatibility among products. The VXS specification defines a payload card; a switch card; and a new, high-bandwidth P0 backplane connector. It also retains the standard P1 and P2 parallel VMEbus connectors. Each P0 fabric port comprises two sets of four ganged serial-bit channels, one set for input data and the other set for output data. The specified P0 connector technology supports data rates as high as 10 Gbps for each serial channel. Payload cards are simply standard VMEbus processor, memory, or I/O boards with the addition of the new VXS-fabric interface. With no P1 and P2 connectors, switch cards have the same form factor as payload cards and include as many as 18 full-duplex serial connectors plus a power connector. The switch card contains the fabric switching necessary to route serial data between payload cards. To remain fabric-agnostic, VITA 41 sub specifications define switches and payload cards for InfiniBand, serial RapidIO, gigabit Ethernet, and PCI Express. David French, director of business development at SBS Technologies, says, “VXS evolves the VMEbus infrastructure and nurtures the VMEbus market. It offers a low-risk, evolutionary product-development path consistent with VME life-cycle advantages.”

The VXS requires a special fabric-compatible backplane that supports two to 20 payload cards and one or more switch cards. A full-width backplane holds nine payload cards on each side and two switch cards occupying the two center slots for a total of 21 boards. With two switch cards, each payload card can connect to any other payload card through two redundant paths. Many fault-tolerant and high-availability applications require this dual redundancy. Hybricon offers a family of VXS backplanes with two switch-card slots and as many as 18 payload slots. The company constructs the boards in a 20-layer, low-noise stripline design with the outside layers incorporating a chassis ground-EMI shield and rigidity stiffeners every two slots. Hybricon tests the parallel-VMEbus portion of each board at speeds as high as 320 Mbytes/sec, as the VITA 1.5 2eSSST standard requires. The company also offers 21-slot versions for the VITA 41.1 VXS InfiniBand Protocol Layer Standard and VITA 41.2 VXS Serial RapidIO Protocol Layer Standard. Custom configurations with fewer than 21 slots are also available.

**DATA CRUNCHER**

Tek Microsystems and QinetiQ recently announced the Quixilica Neptune, a VXS-standard product that combines FPGA technology with dual-channel, 2G-sample/sec ADCs for signal-intelligence, radar, and electronic-warfare applications (Figure 1). A Xilinx Virtex-II Pro XC2VP70 FPGA is at the heart of the Neptune product and provides the interface between the ADCs, memories, and I/O resources on the card. Bill Smith, PhD, manager of the Real Time Embedded Systems Group at QinetiQ, says, “Developers can implement their front-end-signal-processing algorithms in the large, user-programmable FPGA on Neptune to reduce the amount of data that needs to be transferred offboard for subsequent processing.” The Quixilica Neptune VXS-1 is available from Tek Microsystems; prices start at $31,000.

The IB4X-V41-AC from SBS Technologies is a 24-port 4X InfiniBand switch card in a VITA 41 form factor.
This switch card delivers high-speed switched serial interconnections on the standard VME backplane and targets embedded systems in the military, COTS (commercial-off-the-shelf), medical-imaging, and telecom markets. The IB4X-V41 has 18 payload connections, four interswitch connections, and two front-panel connectors that designers can convert to fiber through the use of a media converter. At the core of the switch is a single Mellanox Infiniscale III integrated-switch semiconductor providing 480-Gbps bandwidth. The air-cooled IB4X-V41-AC features two front-panel InfiniBand connectors, one 10BaseT/100BaseTx Ethernet port, and one RS-232 port. The fully managed switch card supports hot-swap functions. The IB4X-V41-AC VXS InfiniBand switch is available now for $7500.

Vmetro offers the Phoenix VPF1, a quad-signal-processing card for VME-based systems supporting the VITA 41/VXS standard. The VPF1 provides dual PowerPC processors and dual Virtex-II Pro FPGAs, as well as two 4×, high-speed serial links for VITA 41 VXS standard fabric connectivity (Figure 3). "VXS provides a standard mechanism for high-performance, low-latency, board-to-board communications," says Andy Stevens, Vmetro's vice president. "It is perfect for those designers requiring efficient and scalable multiprocessing but who do not want to be locked in to proprietary systems." Vmetro also announced TransComm, a software library for VXS-based interprocessor communications to ease the programming burden with high-performance-multiprocessor applications. TransComm comprises routines that enable prioritized data movement and message passing between tasks; the tasks may reside on any processor, board, or set of boards connected through VXS-switched fabrics.

**MORE PINS, PLEASE**

One of the major limitations of VME and even VXS is the number of signal pins interfacing to the backplane. Many system designers feel that the 335 signal pins of the P0, P1, and P2 connectors on a 6U VMEbus card are inadequate for modern, high-performance embedded-system projects. A pending VITA 46 update replaces the VMEbus connectors with a Tyco/FCI MultigigRT seven-row connector that provides high-speed serial fabric for all board-to-board communications (Figure 4). This modular connector comprises a series of interchangeable wafers for single-ended or differential pairs rated to 6.25 GHz and power. The wafers have their own ESD ground plane and contact layout to prevent accidental discharge during handling. The connector provides 48 single-ended signals and 192 differential pairs.

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**Figure 3** The VPF1 quad-signal-processing card from Vmetro provides dual PowerPC processors and FPGAs plus high-speed serial links for VXS connectivity.
Although dimensionally and electrically compatible with standard VMEbus modules, VITA 46 sacrifices backward compatibility to secure maximum performance. Savvy backplane designers have proposed hybrid VITA 46 configurations, even with the intentional incompatibilities, that allow each generation to coexist in the same chassis. Like the VXS standard, VITA 46 defines specific fabric configurations in subspecifications.

Although VITA 46 hardware has yet to appear, VMEbus manufacturers have developed product proposals to demonstrate the effectiveness of fabric systems. For example, the SVMX/DVMX-185 single-board computer from Curtiss-Wright Controls Embedded Computing is the first member of the company’s VITA 46-based product line. This single-board computer will feature Freescale’s 8641 PowerPC processor as well as integral high-bandwidth, low-latency ASI (Advanced Switching Interconnect) to exchange data with other single-board computers and I/O cards at fabric data rates. The SVMX/DVMX-185 also supports a bridging mechanism to support integration with RapidIO-based multicore computing clusters. The 185 will host two XMC (switched-mezzanine-card) modules, providing support for both PCI Express connectivity to the XMC and high-speed I/O from the XMC to the backplane. In addition, the SVMX/DVMX-185’s ESD-protected connector system, with optional top and bottom covers, allows users to safely handle the device in flight-line environments in which standard ESD precautions are impractical.

The VMEbus standard has survived more than 20 years by balancing long-term system availability with strategic technology updates. Just as the standard seems doomed to obsolescence, clever designers have devised modifications that extend the bandwidth and retain compatibility with VMEbus hardware. Ray Alderman, VITA’s executive director, said, “Unlike commodity-board markets, such as the telecommunications industry, VME appeals to markets that need intellectual-value-added applications. The aerospace, defense, manufacturing, and medical industries are great examples of those that need the values that VME provides.”

Although the latest round of updates, VITA 41 and 46, allow VMEbus-embedded-system designers to move into the high-bandwidth realm of switched-fabric technology, new problems emerge. The failure of the market to adopt one fabric standard forces designers to make an educated guess and face interoperability issues with manufacturers that choose a different standard. The new VITA 46 connector arrangement will also create design headaches for designers that want to merge the new-generation hardware into older designs.

REFERENCE


FOR MORE INFORMATION

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www.cwcembedded.com

Framatome Connectors International
www.fciconnect.com

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Hybricon
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VITA (VMEbus International Trade Association)
www.vita.com

Vmetro
www.vmetro.com

You can reach Technical Editor Warren Webb at 1-858-513-3713, 1-858-486-3646 (fax), and wwebb@edn.com.