

Board standards seek THE HOLY

AS EXPECTATIONS FOR EMBEDDED SYSTEMS SOAR, STANDARDS ORGANIZATIONS ARE SCRAMBLING TO OFFER DESIGNERS THE BEST COMBINATION OF COST, SIZE, RELIABILITY, AND PERFORMANCE.

Restricted budgets and shortened schedules have forced design teams to eschew proprietary designs and adopt open standards for low- to medium-quantity, high-performance embedded projects, such as medical instrumentation, military systems, communications installations, and process automation. Their challenge is to select a standard that can deliver the performance, form factor, and cost necessary for the current project and offer ample expansion for expected updates to data rates and processing requirements. Today's board-level standards include names such as VMEbus, PCI, CompactPCI, PC/104, and AdvancedTCA (Advanced Telecom

Computing Architecture), plus a variety of stand-alone modules and daughter-cards. Each standard targets a different group of users and receives support from an industry group responsible for changes and extensions necessary to keep the specifications viable as performance expectations advance.

Embedded-system designers rely on open standards to ensure an ample selection of pre-engineered, off-the-shelf system components to satisfy at least some of the requirements of each new project. Open standards allow designers to purchase components from any number of vendors and ensure hardware and software interoperability. Standards-

based system enclosures, processor cards, peripherals, and off-the-shelf user interfaces may reduce a typical embedded-system project to little or no hardware design and the application-specific software. Industry standards ease the software-development effort by providing access to compatible operating systems, vendor-supplied drivers, and sample source code. Board standards also eliminate the trial-and-error design iterations necessary to get the best cooling performance and mechanical alignment.

Although board standards try to appeal to a large segment of the embedded-system industry, inherent problems exist in the specification-development and -ap-

GRAIL

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proval process. In general, standards organizations are slow to respond to technology advances, because they must wait for a consensus of their members before finalizing updates. Yet, if they attempt to keep up with early changes, the number of options confuses the industry and reduces the probability of interoperable products. For example, the AdvancedTCA standard has several alternatives for serial data exchange, including Ethernet, Fibre Channel, InfiniBand, StarFabric, PCIe (PCI Express), and RapidIO. Although some board vendors have developed unique designs to accommodate multiple options, the failure of the industry to settle on one or two switched-fabric technologies is a possible flaw in the continued success of COTS (commercial-off-the-shelf) products.

GOLDEN OLDIES

Standards organizations must also face the issue of legacy compatibility when upgrading or extending the performance level of board specifications. Designers want a large selection of compatible boards, but a major upgrade to the standard could render a large segment of products inoperable with new hardware. In general, most standards allow you to locate both old and new technologies in the same system with nonoverlapping card-edge connectors or special backplanes that provide each version a few slots. For example, the VMEbus standard is the oldest of the current embedded-system architectures, yet most of the first products are still compatible with the latest products. Standards must also address long-term availability, a prime requirement for high-performance embedded products. Although the average life of desktop components is about 18 months, users expect typical embedded products to remain in service for five years or more.

CompactPCI also has a history of updates in search of the right combination of features to satisfy much of the embedded-system community. CompactPCI packages low-cost, PCI-based desktop hardware into a rugged form factor, giving embedded-system developers access to off-the-shelf silicon and desktop software applications. The PICMG (PCI Industrial Computer Manufacturers Group) controls the CompactPCI specification, which it bases on the Eurocard industry

AT A GLANCE

- ▣ Standards organizations must constantly update board specifications to enable an ample supply of pre-engineered, off-the-shelf products for embedded-system designers.
- ▣ Multiple serial-communications options in board-level specifications can lead to industry fragmentation and product-interoperability issues.
- ▣ CompactPCI Express uses silicon and software from the desktop to enable a high-performance, rugged, yet low-cost embedded-system architecture.
- ▣ AdvancedMC modules serve as mezzanine cards for AdvancedTCA and plug directly into the backplane for the new MicroTCA system standard.

standard defining both 3U and 6U board sizes. The more popular 6U version has as many as five connectors on the rear of the card, allocating two for the CompactPCI bus and the remaining three for optional user-defined I/O connections. Through a series of updates for high-performance applications, PICMG has extended the CompactPCI specification to include a packet-switching backplane that adds dual-switched 10/100/1000 Ethernet fabrics to the user-defined pins.

More recently, PICMG followed the lead of desktop technology and incorporated PCIe into the CompactPCI specification. CompactPCI Express offers scalable high-bandwidth datapaths, packetized data protocols, and compatibility with PCI hardware and driver software. The basic PCIe link comprises two signal paths that use LVDS (low-voltage differential signaling) and constant-current line drivers to communicate at 5 Gbps in each direction. You can increase the bandwidth of an individual PCIe link by simply adding signal pairs, or “lanes,” until you reach the desired performance level. MEN Micro offers a 3U CompactPCI Express single-board computer that features the Intel 2.16-GHz Core 2 Duo processor (**Figure 1**). Highlighting Intel’s Mobile 945GM Express chip set, MEN Micro’s F17 includes six PCIe lanes as well as two SATA (Serial Advanced Technology Attachment) lines. The board’s memory complement comprises 4 Mbytes of L2 cache integrated into the Core 2 Duo and as much as 4 Gbytes of fast DDR2 DRAM. Standard I/O on the front panel includes a VGA connector, two Gigabit Ethernet interfaces connected using PCIe, and two USB 2.0 ports. Because it employs components from Intel’s embedded-system line, the F17 has a guaranteed minimum standard availability of five years. MEN



Figure 1 Conforming to the CompactPCI Express standard, MEN Micro offers a 3U single-board computer that features the Intel 2.16-GHz Core 2 Duo processor.

Micro provides board-support packages for Windows, Linux, VxWorks, and QNX. The price for the F17 is \$2920.

SCRATCH START

Another approach to finding the perfect architecture for a range of applications is to start from scratch and create a new specification, basing it on the latest technology without regard for legacy products. For example, the AdvancedTCA, which debuted in 2003, created an entirely new set of board, backplane, and software specifications for the next generation of telecom equipment. With a larger form factor, high-availability features, and high-speed fabric interconnections, AdvancedTCA promised to be a viable off-the-shelf alternative to

the proprietary equipment prevalent in the telecom industry. The AdvancedTCA specification provides hot-swap capability for all boards and active modules, allowing systems to achieve and even exceed the elusive “five-nines” availability (99.999%). The fabric interface provides a full mesh interconnection, in which each slot has a direct connection to every other slot.

For maximum versatility with high-performance applications, AdvancedTCA designers added replaceable plug-in modules or daughtercards with many of the same features as the base architecture. The resulting AdvancedMC (Advanced Mezzanine Card) standard of-

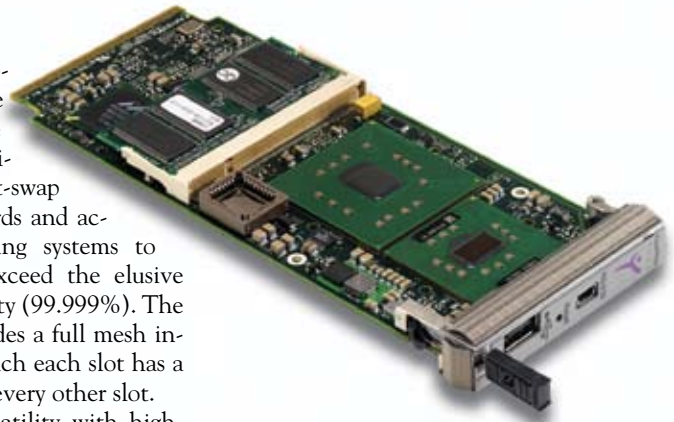


Figure 2 The KosaiPM is an AdvancedMC processor module featuring hot-swap capability and both PCI Express and dual Gigabit Ethernet interfaces.

STACKABLES SEEK A NEW DIRECTION

Board standards either transform themselves to adapt to the latest system requirements or fade into obscurity, like the S-100 bus or Multibus. The PC/104 standard has been struggling of late to deal with the end of ISA-bus silicon. Although the PC/104 Consortium has updated the standard to include the PCI bus (PC/104-Plus) and then to omit the ISA bus (PCI-104), most off-the-shelf boards still require the ISA signals to operate. PC/104 is popular among embedded-system designers because it requires no backplane and allows modules to stack like building blocks. Mounting holes in the corner of each 3.55×3.775-in. module allow you to fasten the boards to each other with standoffs.

Micro/sys, a long-time PC/104 vendor, recently started a campaign to

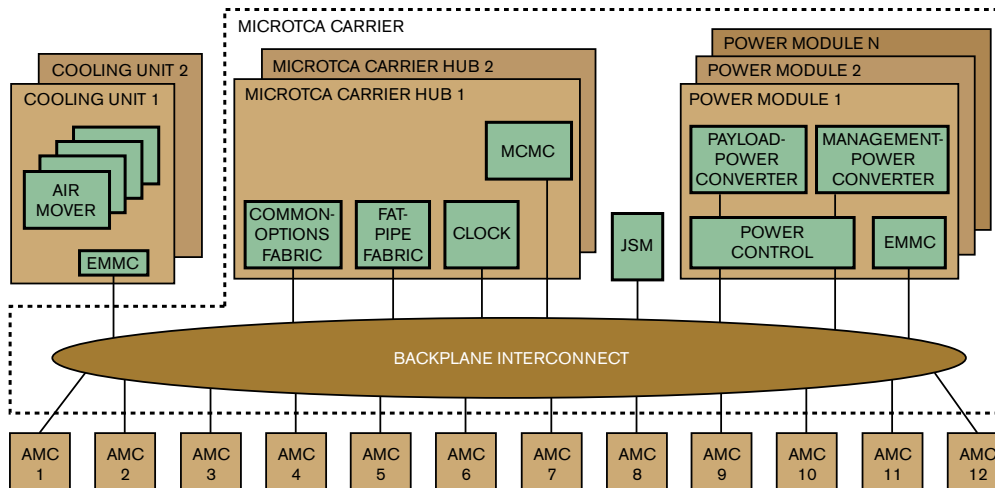
create an entirely new stackable architecture, borrowing the form factor from PC/104. The new architecture uses a more modern communications protocol, USB, but retains the size and stacking advantages of PC/104. StackableUSB supports as many as 16 peripheral boards, takes advantage of USB plug-and-play features, and eliminates the cable with a built-in stack-through connector. To encourage support from a variety of vendors, Micro/sys has already announced a CPU board and a general-purpose I/O card. The USB148 I/O module (Figure A) delivers 48 digital TTL I/O lines plus three 16-bit timer/counters. All discrete I/O lines have software-programmable pullups or pulldowns. The core of the USB148 is a 8051-compatible microcontroller unit that runs at 48 MHz and integrates

many peripherals, such as the 10-bit A/D converter, two UARTs, and others that are available to users. Micro/sys provides a predefined protocol that carries data over the USB, so there is no

need for users to develop code for microcontroller. The USB148 starts at \$125 (one). You can follow the progress of the StackableUSB standard at www.stackableusb.com.



Figure A Although the industry has not yet approved it as a standard, the StackableUSB I/O module from Micro/sys includes 48 digital TTL I/O lines plus three timer/counters.



NOTES:
MCMC=MICROTCA CARRIER MANAGEMENT CONTROLLER.
EMMC=ENHANCED MODULE MANAGEMENT CONTROLLER.
JSM=JTAG SWITCH MODULE.

Figure 3 A typical MicroTCA system comprises as many as 12 AdvancedMCs, carrier hubs, power modules, a cooling subsystem, and a backplane interconnect.

fers designers a hot-swappable, field-replaceable module to lower maintenance costs and reduce downtime. AdvancedMC modules feature remote management and switched-fabric technology in an approximately 3×7-in. form factor.

Modules come in single- or double-size configurations with compact, midsize, and full-size faceplates. AdvancedMC employs a subset of the same IPMI (Intelligent Platform Management Interface) that AdvancedTCA carrier cards

require. This management-interface specification allows local and remote monitoring of equipment for power management, cooling, electronic keying, and hot-swap transactions.

Emerson Network Power, formerly

Artesyn Communication Products, recently announced an AdvancedMC module that it bases on the Intel Pentium M processor (Figure 2). The KosaiPM provides the localized horsepower necessary for applications such as protocol processing, packet processing, data management, and I/O management. The module features a low-power processor operating at as much as 1.8 GHz, 2 Mbytes of Level 2 cache, as much as 2 Gbytes of DDR SDRAM with ECC (error-correction code), a USB 2.0 interface, and a front-panel RS-232 console interface. To support high-speed packet-data transfers on and off the card, KosaiPM features both PCIe and dual Gigabit Ethernet interfaces to the baseboard. KosaiPM also features an I²C-based IPMI that enables you to monitor the module and remotely control it. KosaiPM is also hot-swappable, reducing spares costs and mean time to repair.

With all the high-power, hot-swap, switched-fabric, and management features of AdvancedMC, designers considered using these modules to plug directly into a backplane for small, stand-alone systems. After considerable effort



Figure 4 The new 5U MicroTCA shelf from Elma Electronic features a 14-slot dual-star backplane with 10 AdvancedMC, two power-module, and two carrier-hub slots.

to get an industry consensus, PICMG released the MicroTCA specification in July 2006. MicroTCA provides a stand-alone chassis with a backplane that directly accepts AdvancedMC cards, thereby eliminating the AdvancedTCA carrier board. The smaller form factor makes the concept viable for lower budget applications in telecom and a range of embedded-system projects.

The short-form version of the MicroTCA specification, available at the PICMG Web site, defines a minimum MicroTCA system as a collection of interconnected elements consisting of at least one AdvancedMC module; at least one MicroTCA carrier hub; a power module; and the interconnect, cooling, and mechanical resources needed to support them. A MicroTCA carrier hub

combines the control and management infrastructure and the interconnect-fabric resources necessary to support as many as 12 AdvancedMCs in a single module. The MicroTCA power module takes the input supply and converts it to 12V to provide payload power to each AdvancedMC module. As an example, a typical MicroTCA system comprises as many as 12 AdvancedMCs, one or

two carrier hubs, multiple power modules, load sharing, a cooling subsystem, a backplane interconnect, and the mechanical elements (Figure 3). You can duplicate active components to provide redundancy. Elma Electronic recently announced a new 5U MicroTCA shelf with a 14-slot dual-star backplane in the single-module, full-size format. The backplane provides 10 AdvancedMC,

two power-module, and two MicroTCA carrier-hub slots (Figure 4). Three plug-in fan trays with air filtering provide cooling. Prices for the 5U MicroTCA shelf starts at less than \$2000, depending on options.

Whether a standard evolves from a previous version or starts from scratch, the developers are searching for the same thing: a stable open specification that allows diverse manufacturers to produce technologically advanced boards that work together for the lowest possible price. An ample supply of readily available COTS boards is vital to the high-performance, embedded-system-development process. As embedded-system developers concede, there is no Holy Grail of open standards that applies to every project, and there probably never will be. Instead, as electronics technology continues to conform to Moore's Law, you will see a steady stream of standards updates plus plenty of completely new ideas (see sidebar "Stackables seek a new direction"). The alternative is to return to the long lead times and hefty budgets of in-house, proprietary designs. **EDN**

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