MicroTCA and AMC Team for Military Duties

Fitting in nicely with the military's quest of a compact, network-friendly embedded form factor, MicroTCA is gathering mindshare fast. Mechanical changes aimed at ruggedizing the MicroTCA spec could place it into the forefront of system architecture alternatives.

Robert C. Sullivan, VP of Technology
Hybricon
Clayton Tucker, Senior Marketing Manager,
Emerson Network Power

For the first time since the introduction of VME 25 years ago, an embedded computing architecture is emerging that is capable of serving a broad cross section of market segments: commercial, industrial, medical, telecommunications, and now military systems. This emergence of the MicroTCA architecture—originally developed for telecom and networking applications—coincides with a push underway in military and aerospace design to replace proprietary architectures with off-the-shelf embedded systems that can successfully integrate high-density, multicore processors and multi-compute nodes. Now, the MicroTCA architecture is evolving ruggedized construction specifications that can support operation in the harsh environments of military and aerospace systems.

Two trends are defining the next-generation military system designs: increasing complexity and data handling, and a move to off-the-shelf embedded computer technologies. To address the complexity and data requirements, system designers are turning to network-centric systems that simplify connection, coordination and high-speed data transfer among nodes. Previous generations of embedded networking equipment were developed for enterprise applications and lacked tolerance for the environmental hazards that face military systems, but the telecom industry's MicroTCA architecture is an exception. It's evolving to address ruggedization requirements and become the basis of next-generation military system designs.

Net-Centric Requirements

Next-generation military systems will need to handle massive amounts of information traffic. The concept behind the Future Combat Systems (FCS) program (Figure 1), for example, calls for command and intelligence structures to become highly coordinated with the man in the field. Satellite information and video from unmanned autonomous vehicles (UAVs) in the air and on the ground will be sent directly to the troops that need the tactical support. Wearable computer-based health vests will continually update troop status to central command, and personal location devices will help coordinate air support with ground troops.

While all that sounds like science fiction, it lies within the range of current technology. The key to making it all work is to have systems designed to be part of a massive network for the exchange of information, including data, video and voice communications. The network must be easy to expand and maintain, exhibit high availability, and support the addition and removal of nodes without interruption of traffic. These various forms of information or data are the lifeblood of the theatre of operations. The optimal movement and use of that data across the networks will drive the real viability of future battlefield platforms. This communications backbone is the essential element of the integrated battlefield and is uniquely suited for a MicroTCA communication-based platform.

The Internet and the infrastructure it runs on is such a network, and its technology is widely available for military system developers to apply. But there are two main problems. First, the commercial-grade equipment of the Internet's underlying telecommunications network infrastructure is often proprietary in nature and is thus expensive, has limited availability, and is difficult to adapt to custom requirements. Second, telecom networking equipment was designed for indoor operation and generally will not tolerate the shock, vibration and temperature conditions of field environments.

MicroTCA Addresses Rugged Needs

Those problems are rapidly evaporating, however, with the emergence of MicroTCA. The architecture arose specifically to solve the first problem: the high cost of developing and supporting proprietary networking equipment architectures. The PCI Industrial Computer Manufacturer's Group (PICMG) addressed the problem by creating open system, hardware and software specifications tackling the needs of telecommunications and networking equipment.

PICMG's initial effort resulted in the Advanced Telecommunications Computing Architecture (ATCA), which uses a modular design approach that plugs a variety of blades into a high-speed, protocol-agnostic, switched-serial backplane. The blades are also modular, configurable with I/O and computing functions on Advanced Mezzanine Card (AMC) modules, which are large enough to carry significant functionality but small enough to fit into a shoebox-sized housing, that plug onto the blade. The ATCA specifications define the entire base system; including cards, cage, power supply, cooling and system software for built-in test, fault monitoring and system management.

While ATCA targeted large-scale central-office installations, PICMG was tasked to address the need for smaller and less demanding designs. As a result, PICMG adapted the ATCA architecture to create MicroTCA. MicroTCA uses the same functional architecture, system management software and AMC modules as ATCA, allowing many system hardware and software elements created for ATCA to also serve in MicroTCA designs without modification. This commonality has the side benefit of increasing the applications base for AMC modules, fostering innovation and lowering their cost.

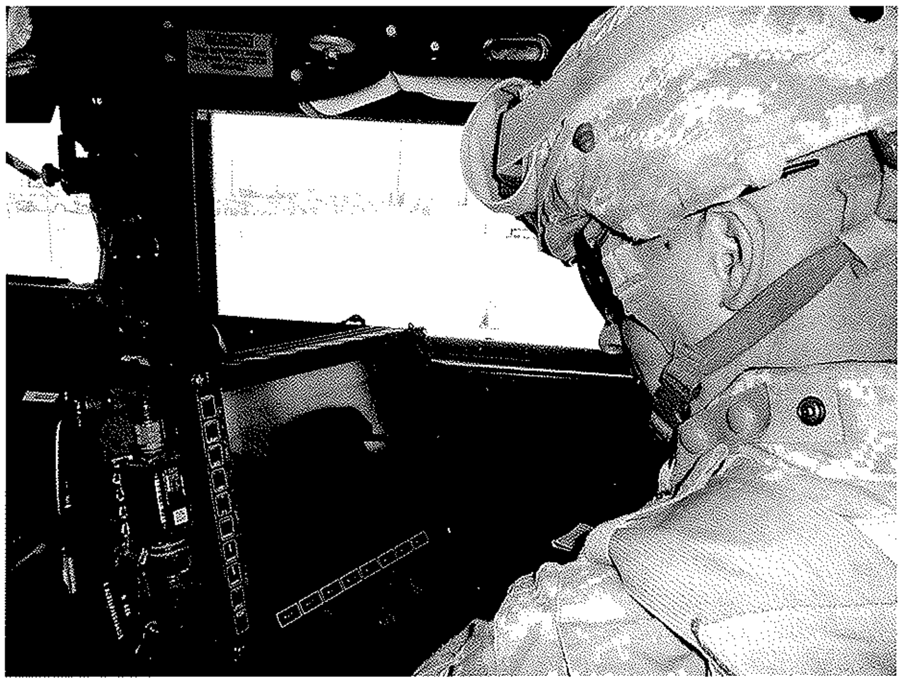

Figure 1

Exemplifying how next-generation military systems will need to handle massive amounts of information traffic, the Future Combat Systems program relies on a network capable of getting satellite information and video from unmanned autonomous vehicles (UAVs) in the air and on the ground and sending it directly to the troops that need the tactical information. Shown here a soldier reviews networked data during an FCS demonstration.

The primary difference between the two architectures is mechanical; with MicroTCA, AMC modules plug directly into a backplane rather than onto carrier cards as in ATCA. There is also a movement of some switching and control functions from ATCA carrier cards to an AMC-sized MicroTCA Carrier Hub (MCH) in MicroTCA. The AMC cards themselves, however, are identical in both systems.

One of the outcomes of this mechanical difference is considerable flexibility in physical configuration, as shown in Figure 2. Unlike the massive ATCA system design, a full MicroTCA system can be implemented with as few as two AMC modules, allowing extremely compact designs. MicroTCA systems can also be larger, with as many as 12 cards in a rack, where higher performance is required. This flexibility gives military system designers the freedom to implement systems in racks, cubes, or many other configurations and still conform to MicroTCA specifications, solving installation challenges while gaining access to MicroTCA's numerous off-the-shelf components.

Similarly, the protocol-agnostic nature of the MicroTCA's serial backplane provides flexibility in design choices without losing off-the-shelf benefits. Systems can be created with the Internet Protocol (IP) as the backplane's native format, or can just as easily be created to interface with another high-speed serial protocol unique to a military system's needs. The backplane even supports the mixing of protocols to simplify bridging between disparate systems.

High Availability Built In

Telecom's need for high-availability system operation, which mirrors that of military systems, prompted PICMG to design AMC modules to support advanced features such as electronic keying and automatic fail-over in case of fault. Working in conjunction with the system management software, the modules allow remote power control for hot-swap operations, incorporate built-in test capability, and permit the system to automatically identify new modules and reconfigure appropriately. Together with the modularity inherent in the MicroTCA architecture, these AMC module and system management features also greatly simplify system maintenance, repair, modification and upgrade.

The AMC modules and other off-the-self components that are available for MicroTCA span the entire system structure. Cage mechanics, power and cooling subsystems, and backplane are all covered in the specifications and thus available from multiple vendors as interchangeable units. A wide range of interoperable AMC modules are likewise available with such functionality as high-performance CPUs, high-speed serial interfaces, mass storage systems, and other telecom system needs. Further, the market for MicroTCA system elements has been growing beyond telecom, adding to the diversity of functions available. The result is a hardware architecture with rich support of off-the-shelf equipment that addresses many of the functional needs of next-generation, network-centric military systems while providing enough flexibility to address specialized system needs, as well.

The embedded hardware support that MicroTCA provides has its match in embedded software support that can apply to military system needs. In addition to defining system hardware, the ATCA and MicroTCA specifications define a complete base system behavior including fully defined system management functionality. As a result, system management software for MicroTCA has become available as commercial products. Emerson Network Power's SpiderWareM3 middleware, for example, helps simplify the managing, monitoring and maintaining of MicroTCA systems. It gives an operator graphical access to and control of system behaviors such as module discovery and identification, environmental monitoring and alarm settings, fan speed and operation, and software loading.

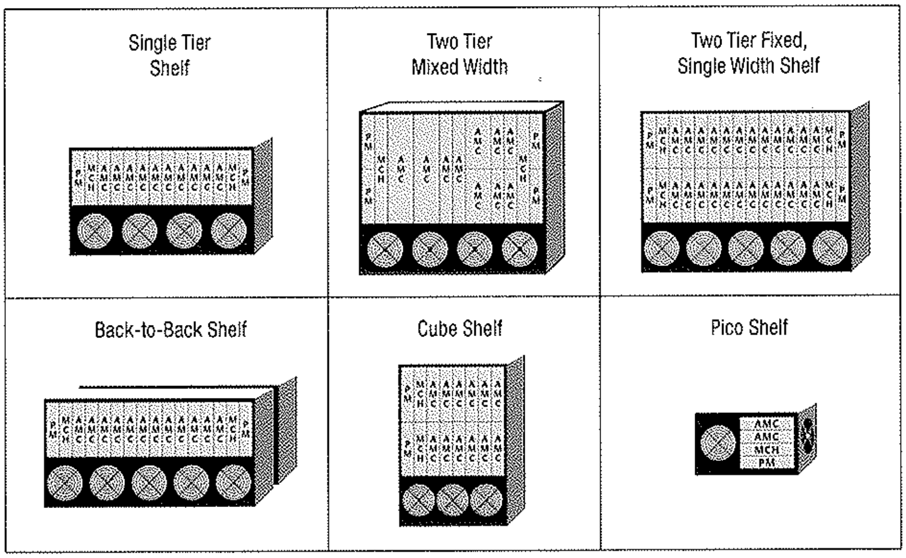

Figure 2

Design flexibility is a hallmark of the MicroTCA specification, as shown by the wide variety of system footprints the specification allows.

Similarly, the open nature of the MicroTCA standard along with its built-in support for high-availability (HA) operation has allowed HA middleware to arise. Some of this is freely available. The Service Availability Forum—an industry-wide consortium—took advantage of features built into the MicroTCA specification to create open-source HA middleware that developers can adapt to their unique needs. For those that need full engineering support, commercial HA middleware is also available.

Such commercial software supports the ease of operation and maintenance essential for military systems by simplifying operations. It also provides an opportunity to implement system operation that is consistent across many platforms. Because it is standards-based, it is assured to be interoperable with specification-compliant system hardware regardless of application. This can greatly simplify military system software design by eliminating the system management design effort and allowing developers to concentrate on applications development, instead.

Addressing Rugged Environments

The cost, availability and development benefits of open-specification design solve the proprietary design problem and, together with the many attributes that support mission-critical operation, make MicroTCA a promising architecture for implementing network-centric military systems with off-the-shelf components. Recent efforts within the PICMG organization are now addressing the remaining weak area, the operating environment. The original PICMG specification—MicroTCA.0—targeted NEBS-grade environmental conditions of offices and outbuildings. The temperature range involved runs from -5° to +55°C ambient temperature range. Shock and vibration resistance are minimal, representing normal shipping and handling, installation activity, earthquakes, and the like.

Market interest in the MicroTCA architecture outside of telecommunications, however, has prompted PICMG to extend its specifications to address harsher environment installations, including outdoor and industrial settings as well as vehicle mounting in trucks, trains and commercial aircraft. The organization's efforts are running in two phases. A ruggedized, air-cooled specification—MicroTCA.1—is up first, scheduled for release this year. A second extension, the MicroTCA.2 conduction-cooled system—MicroTCA.2—is also under active development but is at least a year away.

The goal in both of these efforts is to preserve cost and availability benefits of MicroTCA-compliant designs by keeping intact as much of the original design as possible. Part of the approach includes the use of component selection during board build to extend temperature tolerance. Another part is to augment, rather than change, mechanical designs to boost ruggedization. Such augmentation includes additional stiffeners and retention devices that can be applied to standard board designs. Extensive testing has proven that the current card-edge connector system can meet a 5G to 25G shock and 10G sinusoidal vibration immunity requirement with such augmentation.

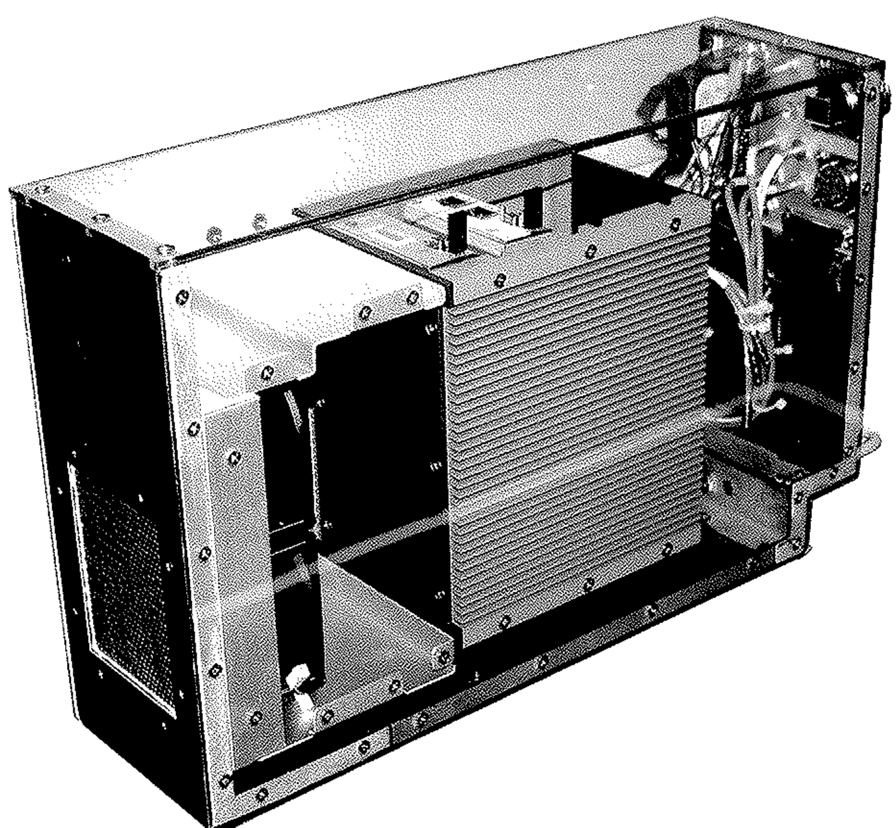

Figure 3

This ruggedized MicroTCA system is a harbinger of conduction-cooled MicroTCA specifications currently under development within PICMG.

Air-Cooled or Conduction-Cooled

The target specifications for air-cooled MicroTCA.1 include several possible ambient operating temperature ranges, the broadest of which is -40° to +70°C. The conduction-cooled MicroTCA.2 specification aims at meeting many of the ANSI/VITA 47 environmental levels, including an operating temperature range of -40° to +85°C. Although the MicroTCA.2 specification has not yet been fully defined and approved, conduction-cooled MicroTCA units already available from companies such as Hybricon (Figure 3) point the way and prove the concept.

The jury is still out on the mechanical changes needed for MicroTCA.2, however. The use of wedge locks and conduction plates on the AMC modules to carry component heat to the frame is already clear, requiring changes to the card cage spacing and dimensions. The edge connector is the greater unknown as it is not clear that such a connector will withstand the most severe target shock and random vibration requirements of ANSI/VITA 47. Although preliminary testing indicates that some versions of the connectors will be acceptable for many applications, the committee plans extensive testing before making a final recommendation, in order to fully characterize the conditions for which a variety connector options have sufficient reliability.

PICMG's work is making MicroTCA an ever-more practical option for use in all but the most demanding military applications. It is a proven architecture, representing low risk to developers. It simplifies design because the system foundations along with a full range of system components are already fully defined and available. Yet, it provides the design flexibility needed to address unique application needs when suitable off-the-shelf elements are not available. The fully developed and thriving ecosystem of vendors developing MicroTCA products along with substantial interest in the architecture beyond telecom ensures that when the ruggedized specifications are in place, MicroTCA products covering a range of environmental options will quickly become available. MicroTCA will thus give military designers access to low-cost embedded computer system elements that match their functional and environmental requirements, allowing creation of network-centric systems for the next generation of military equipment. ▮▮

Emerson Network Power
Tempe, AZ.
(800) 759-1107.
[www.emersonnetworkpower.com].

Hybricon
Ayer, MA.
(978) 772-5422.
[www.hybricon.com].