MicroTCA – a new standard for the battlefield

By Rob Persons

Although you may not see specific references to battlefield applications as you peruse this issue's MicroTCA Product Guide*, Rob makes the case here for MicroTCA as a viable architecture for many new military systems such as the Warfighter Information Network – Tactical (WIN-T).*

The rapid and aggressive transformation mandated by the Department of Defense for integrated battlefield management, or the network approach to warfare, has far-reaching influence over military technology development and insertion. The transformation of the battlefield to interconnect war fighters to their command structure and to other war fighters is driving the need for new communications strategies and system architectures that can maximize the amount of Commercial Off-the-Shelf (COTS) content and reuse. Developing high performance military systems that can leverage large economies of scale has been an elusive reality because most current architectures are tightly coupled to the industry that defined the standard. At the same time, maximizing reuse of common nondifferentiating technologies, such as CPU cards and disk modules, has been complex and difficult.

Rapid modernization is only possible when new systems are developed around advanced or superior open standard hardware and software. Not using COTS solutions has become too expensive and slow to combat the heightening global and homeland security requirements. In addition, resources for modernization are limited, so military and federal agencies are looking for new open standard approaches for rapid, cost-effective development and deployment.

The MicroTCA standard based on the Advanced Mezzanine Card (AdvancedMC) was ratified by PICMG in July 2006. Basing MicroTCA on AdvancedMC modules enables the standard's rapid development and adoption. Companies have a framework to develop new network-centric platforms for small network devices that address both telecommunications and battlefield systems.

Network-centric warfare

One effort to modernize the battlefield is a program called Future Combat Systems (FCS), which will improve communications and data connectivity between battalion headquarters and all command structures below, down to the individual soldier. Radio modernization has been underway for several years through the Joint Tactical Radio System (JTRS) program, where a single radio will perform a variety of functions by dynamically changing the waveforms. Rear echelon and maneuvering battalions of the Future Force (FF) will share voice, data, and video on the battlefield through a network developed as part of WIN-T to improve situational awareness for all command structure elements. The network is being designed to be extremely mobile, resilient, and adaptable for many battlefield situations.

Developers are adopting Internet Protocol (IP) based strategies for WIN-T to maximize throughput and flexibility for new devices that are being developed for FCS. Compatibility with the Global Information Grid (GIG) will allow military and civilian leadership direct access to the battlefield from around the world. An emerging standard, World Interoperability for Microwave Access (WiMAX), which is a certification mark for products that conform to the IEEE 802.16-2004 family of standards, along with IEEE 802.11, are two wireless protocols that will be used along with other standard IP protocols to improve data throughput in the field. Sprint has recently announced it will deploy a WiMAX network to support 4G wireless phones for making broadband data performance to the phone possible.

Network-centric system architectures

MicroTCA leverages the emerging ecosystem for AdvancedMCs to create a new, flexible, small form factor platform, enabling a variety of system configurations to be created. The MicroTCA specification allows for modular or monolithic chassis configurations from 1 carrier and 1 module to 16 carriers and 192 modules, while ensuring that modules always see the same *virtual* environment. These MicroTCA communications servers, such as the Motorola Centellis 1000 communications server (Figure 1), typically support 2 to 3 independent fabric interconnects on a carrier, where each fabric *port* (differential transmit/receive pairs) is capable of at least 6.25 Gigabaud (5 Gbps) in each direction, and specific ports can be aggregated to form *fat pipes* with higher throughput.

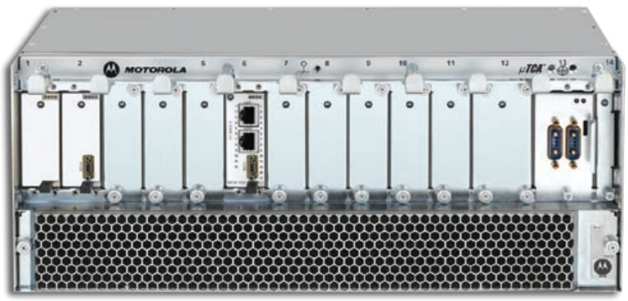

Figure 1

Systems like the Centellis 1000 will support three different fabric protocols simultaneously in a chassis: Gigabit Ethernet, PCI Express, and Serial ATA. The current aggregate carrier (switched backplane) bandwidth is around 40 Gbps, but next generation hubs should exceed this. The MicroTCA specification allows for up to 12.5 Gigabaud per port.

Migration of existing I/O PMCs to the AdvancedMC form factor is straightforward because PCI Express is an extension of standard PCI. PCI Express maintains backward software compatibility to PCI so that drivers and operating system software can be reused. PCI to PCI Express bridges can be incorporated on an

AdvancedMC, allowing reuse of existing PMC card designs. As new controllers are released with PCI Express, MicroTCA can add this new functionality while maintaining more traditional I/O or custom PCI based designs in the same chassis. Also, migrating to a switched serial architecture like PCI Express eliminates the *slowest link* limitations[1].

Applying MicroTCA to WIN-T

Referred to as WirelessMAN or Wireless Metro Area Network, IEEE 802.16-2004 was developed to promote wireless broadband services to the *last mile,* the connection from the street to the home. Operating frequencies in the original 802.16 specification were from 10 GHz to 62 GHz and expanded to include 2 GHz to 11 GHz frequencies with 802.16-2004, though the frequencies will be relegated to licensed frequencies of 2.5 GHz to 2.69 GHz and 3.4 GHz to 3.6 GHz and unlicensed spectrum 5.725 GHz to 5.850 GHz. In late 2005, 802.16e was added and included Orthogonal Frequency-Division Multiplexing (OFDM), where a single transmitter transmits on many (typically dozens to thousands) different orthogonal frequencies, that is, frequencies that are independent with respect to the relative phase relationship between the frequencies[2]. OFDM improves the performance of this wireless protocol, reduces interference between devices, and allows for Non Line Of Sight (NLOS) operation. The IEEE 802.16 standard also utilizes scheduling algorithms that gives all subscribers a controlled access to the network and allows for quality of service control of network traffic.

Army programs are interested in WiMAX because it has been designed to deliver broadband data performance both for fixed and mobile devices. Dynamic creation and maintenance of these mobile networks along with Quality of Service (QoS) that will allow true battlefield situational information between the rear echelon and the advancing troops. WiMAX AdvancedMC modules will be available in the future, and MicroTCA will be the platform architecture best suited for deploying it into the field.

Rugged MicroTCA

Working closely with Motorola, Hybricon has developed a ruggedized MicroTCA ATR chassis that leverages Motorola's commercial MicroTCA platform, while also accommodating double-width modules (Figure 2). The ruggedized ATR platform remains compliant with the MicroTCA specification, and addresses many of the limitations of commercial MicroTCA for military applications:

- The ruggedized ATR chassis uses shock isolation of the MicroTCA card cage inside the ruggedized ATR chassis; this attenuates the level of shock and vibration that is seen by the MicroTCA cards, allowing the chassis to meet stringent MIL-STD-810 shock and vibration requirements
- Military circular connectors for copper and fiber I/O are used to meet military ruggedization requirements for external connectors
- A secondary EMI barrier is used, in addition to aggressive power line filtering, to meet stringent MIL-STD-461 EMI/EMC requirements
- The ruggedized ATR chassis uses the MicroTCA specification's optional locking provisions, to firmly retain the MicroTCA cards into the card cage, providing significant additional resistance to shock and vibration
- Military power supply front ends can be used to meet specific military power supply requirements such as MIL-STD-704 aircraft power or MIL-STD-1275 vehicle power

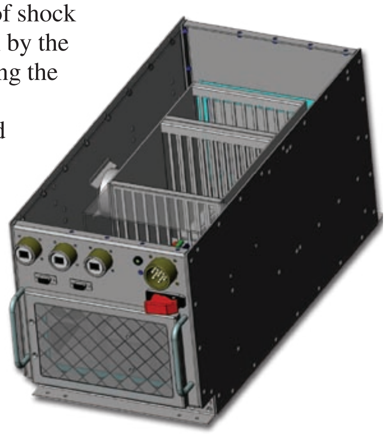

Figure 2

The specifications of the AdvancedMC and MicroTCA cards that are used in a particular application are the limiting factor in determining the system's operating temperature range. Commercial AdvancedMC and MicroTCA cards can satisfy less stringent military temperature ranges. Ruggedized and/or extended temperature range AdvancedMC and MicroTCA cards may be required in some applications. This is similar to the existing VME and CompactPCI form factors.

Rugged MicroTCA enclosures with adapted AdvancedMC modules will allow for a more flexible deployment of new network centric technologies to the battlefield. Adoption of PCI Express and Gigabit Ethernet as the base fabrics of MicroTCA will reduce the complexity of migrating critical military I/O to AdvancedMC form factors and help quickly ramp up the availability of necessary I/O. New AdvancedMCs that can deliver the new wireless technologies to the battlefield are the same technologies that will be used in the next generation mobile phones with high-speed broadband capabilities. But it is the efforts of companies investigating the ruggedization of commercial AdvancedMCs that will help the military utilize truly COTS hardware in the battlefield that is also being deployed in civilian applications.

Summary

MicroTCA has the same potential as VME did 25 years ago to become the standard for multiple industries. Many of the telecommunication industry's COTS advancements will finally unite with the network initiatives found in medical, military, and aerospace to drive true COTS rapid insertion of cost-effective, ubiquitous, high performance, flexible, and scalable platforms.

References

[1] Bringing up to PCI Express from PCI, Intel Corporation White Paper, http://download.intel.com/design/bridge/papers/25375501.pdf

[2] Orthogonal frequency-division multiplexing, Wikipedia, http://en.wikipedia.org/wiki/Orthogonal_frequency-division_multiplexing

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