AN OPEN ARCHITECTURE APPROACH TO NETWORKED TELEMETRY SYSTEMS

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ABSTRACT:

When designing data transport systems, Telemetry and Communications engineers always face the risk that their chosen hardware will not be available or supported soon after the hardware has been installed. The best way to reduce this risk and ensure the longevity of the system is to select an open architecture standard that is supported by multiple manufacturers. This open architecture should also have the ability to be easily upgraded and provide for all of the features and flexibility that are required to be a reliable carrier-grade edge-device.

The PCI Industrial Computer Manufacturers Group (PICMG) developed the MicroTCA open standard to address the specific needs of these Communications and Network System Engineers. This paper describes the MicroTCA architecture and how it can be applied as the ideal edge-device solution for Networked Telemetry Systems applications.

KEY WORDS:

MicroTCA, Edge Device, Multiplexer, COTS

1. INTRODUCTION

An ongoing problem for the telemetry and communications engineer is the lack of availability and support for recently purchased and installed data transport systems. This type of situation has recently become a major challenge for many of our DoD test ranges.

For example, when a manufacturer goes out of business or discontinues a product line soon after the delivery of a major telemetry transport system, the end user is left with equipment that can no longer be supported. When this happens, the equipment typically needs to be replaced, usually at a very high cost to the end user.

Due to the unique nature of some telemetry signals, many of the widely-used and commercially available data transport systems are not designed to ingest and transport all of the different signal types required to support most telemetry applications. Therefore, it is very common for telemetry systems to be custom designed with proprietary hardware architectures to address the data transport needs of our telemetry ranges.

The obvious solution is to design our networked telemetry systems using an open hardware standard and promote interoperability between manufacturers. This not only reduces the end user's risk of system obsolescence, but also encourages manufacturers to be more price-competitive and focus on value-added service in an effort to differentiate themselves from other manufacturers.

2. THE IDEAL NETWORKED TELEMETRY SYSTEM

In order to identify the ideal Networked Telemetry System hardware architecture, we must first identify the needs of the DoD ranges. The specific needs of each range changes depending upon what is being tested and where the test is conducted, but the basic functions of all telemetry transport systems are similar across all ranges. The primary role of any system, regardless of the range, is to accept all types of telemetry data channels and then package that data so that it can be sent over the specified transport link.

Various types of transport links are used to move telemetry data across the DoD test ranges. ATM, SONET, and Ethernet networks are three of the primary transport links used on the ranges today. Depending on the location and terrain of the test site, any combination of satellite modems, microwave transceivers, fiber, copper, and even commercial communications networks are used. The ideal Networked Telemetry System should be able to accommodate any data transport link that is currently used by the DoD.

Many ranges are currently migrating towards using Ethernet as their primary method of transporting telemetry data, mainly because of the cost benefits and commercial availability of Ethernet networking products. Not only should the ideal Networked Telemetry System be able to address all of the current range networks, but it should also have the capability to easily change the link interface without replacing the entire system.

In addition to accommodating and switching between the various network link types, the telemetry system needs to accept all of the data types that exist on the ranges. Synchronous PCM, time code, video, analog, asynchronous, and avionic buses are a few examples of the data types that need to be transported. The types of channels, the number of channels, and the data rates of each channel will typically vary from mission to mission, so modularity is an important feature of the ideal Networked Telemetry System. Field configurable units with hot-swap functionality would allow the user to add and remove various channel types for quick system configuration.

The key features of any carrier-grade communications system are the reliability, availability, and serviceability. The system should provide redundancy and hot-swap capability for all of the modules in the chassis, including the channel cards, the link modules, the power supplies, and even the fans. Redundancy must also be extended to the data buses inside of the unit, as well as the bus controllers and system processors. The ability to remotely monitor the health and status of all modules in each chassis on the network is also very important.

There are other needs more specific to each range and application, but the ideal Networked Telemetry System should be able to address all of these needs. For example, some ranges are very concerned about data throughput delay where others are concerned about channel-to-channel skew. Some ranges have very limited bandwidth where store-and-forward capability is needed, and other ranges have high data rate requirements on some or all channels. Small and/or rugged enclosures are sometimes needed to survive adverse conditions, and many ranges are limited in budget, so affordability is a requirement.

3. WHAT IS MicroTCA?

MicroTCA is a modular platform of open standards that was developed specifically for carrier-grade communications applications. By configuring a highly diverse collection of modules in a MicroTCA system, many different applications can be easily addressed. The common elements defined by the MicroTCA standard allow for the interconnecting of these modules regardless of the manufacturer, while powering and managing them all at high efficiency and low cost.

3.1 BRIEF HISTORY OF MicroTCA

In 1994, the PCI Industrial Computer Manufacturers Group (PICMG) formed as a consortium of companies who collaboratively develop open specifications for high performance telecommunications and industrial computing applications. The purpose of PICMG is to offer common specifications to equipment vendors, thereby increasing equipment availability while reducing costs and time to market.

In 2002, PICMG released the ATCA (Advanced Telecommunications Computing Architecture) specification to address the requirements for the next generation of carrier-grade communications equipment, which incorporates the latest trends in high-speed interconnect technologies, next generation processors, and improved reliability, availability, and serviceability. The ATCA system is a modular architecture that uses large carrier cards for mixing and matching multiple modules into a single chassis.

In 2005, PICMG released the Advanced Mezzanine Card (AMC) specification. The AMC modules are printed circuit boards that are designed to work on any ATCA carrier card. The AMC modules are application specific so that a system can be created in any number of combinations of modules to address a multitude of applications.

In 2006 PICMG released the uTCA (Micro Telecommunications Computing Architecture) specification to address the same requirements as the ATCA specification, but targets the smaller channel count and lower cost needs of the marketplace. The major difference between the ATCA and the uTCA system is that AMC modules can plug directly into the uTCA chassis backplane without the need of the carrier modules used in ATCA systems.

3.2 MicroTCA ARCHITECTURE OVERVIEW

From a high level perspective, the MicroTCA system is comprised of three elements. Refer to Figure 1 for a block diagram of the MicroTCA system.

1. The chassis is the mechanical element that contains several subsystems. Cooling, power, and the backplane interconnect are all resources inside of the chassis that support the functional and management elements.

2. The MCH (MicroTCA Carrier Hub) module is the control and management element whose functions include power delivery, interconnects, and Intelligent Peripheral Management Interface (IPMI) management, among others as defined in the AMC.0 base specification.

3. AMC modules are the primary functional elements of the MicroTCA system. These AMC modules perform various functions such as processing, data I/O, backplane bus control, storage, and network interface.

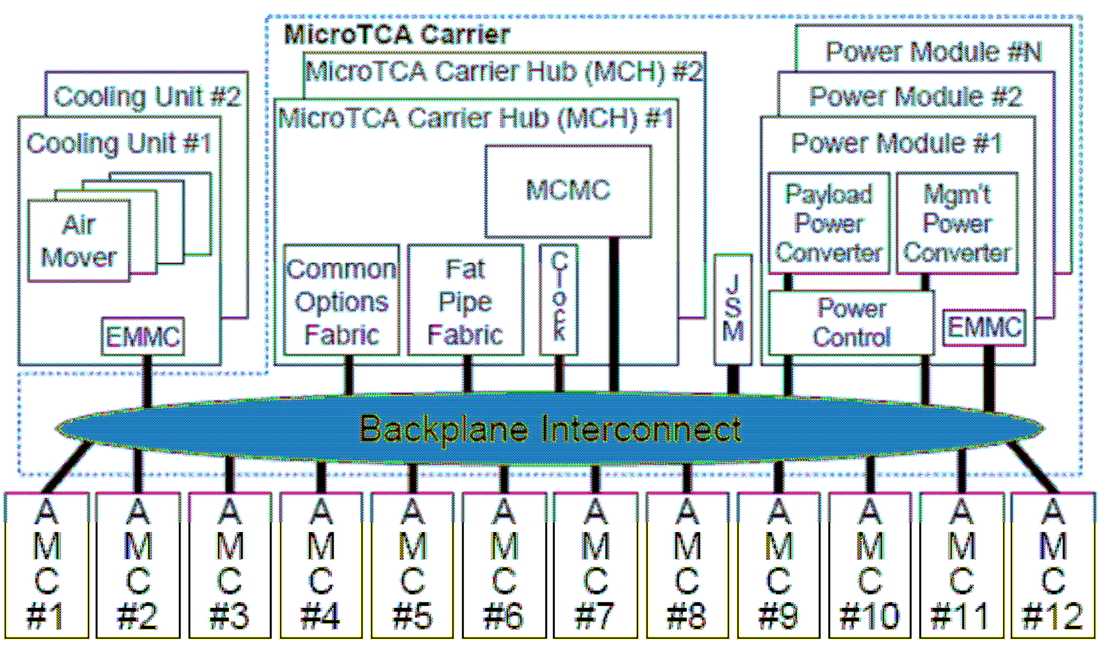

FIGURE 1: The MicroTCA System

A key feature of the MicroTCA architecture is the backplane interconnects. The MicroTCA specification allows for multiple redundant fat pipe buses between AMC modules. One Gigabit and 10 Gigabit Ethernet, XAUI, Serial Rapid IO, and PCI Express are some of the available open-standard pipes available on the backplane. A total aggregate up to 250 Gbps can be realized when maximizing the bus potential.

The Ethernet bus can be configured as a non-blocking dual-star network configuration for full network redundancy. Each module has a connection to each network star, so the removal of a network card, an MCH card, or processor card will not bring down the entire system. User configurations allow for setup of failover and redundancy options.

In a Telemetry Network System application, all telemetry channels can be converted to Ethernet. For multiple manufacturer interoperability, the RCC TMoIP standard 218-08 should be followed. All channels are assigned their own IP port address, and the data can be sent from the channel modules to the link module via the Ethernet buses. So, if the desired telemetry network is IP, the unit simply outputs the IP packets directly to the network from the backplane Ethernet bus. If the desired link is something other than IP, the IP packets are sent to the link module and converted to the proper format.

Figure 2 shows a typical MicroTCA backplane fabric diagram.

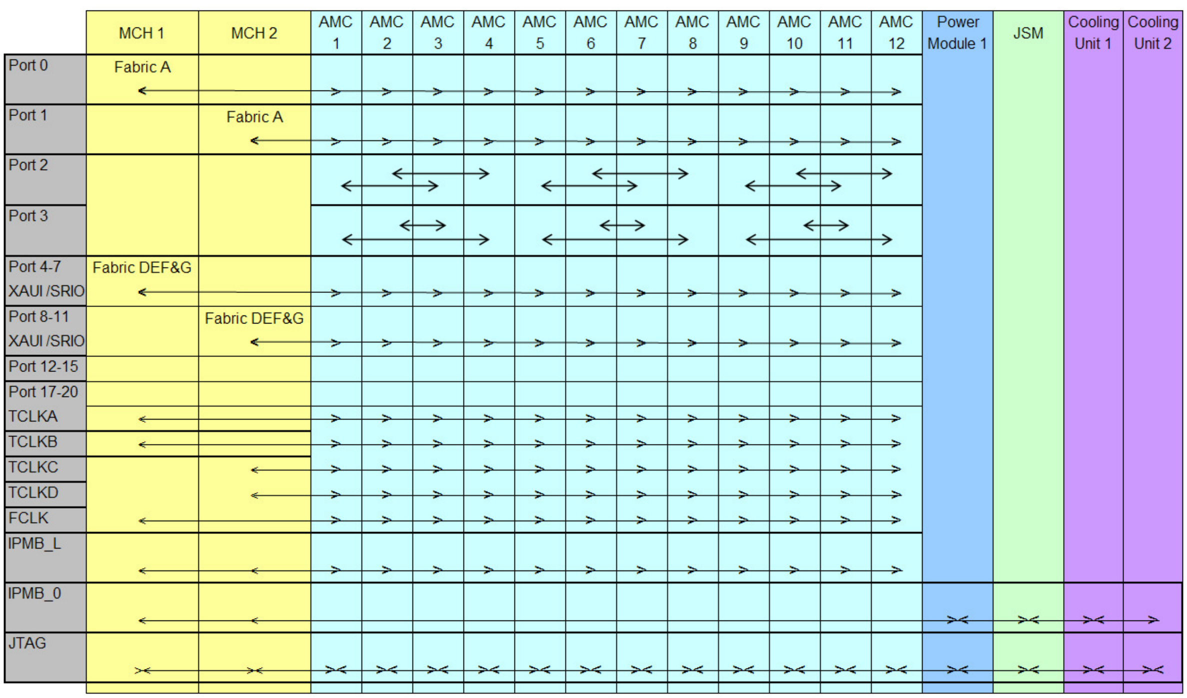

FIGURE 2: The MicroTCA backplane fabric

The power supplies, fans, and each AMC module connects to the IPMI bus. IPMI is an open standard for the health and monitoring of all MicroTCA systems on the network, which enhances availability and serviceability by allowing shelf management to identify faults and take corrective action at the module level.

IPMI utilizes an I2C-based physical interface that allows monitoring of system health characteristics such as voltages, temperatures, and fan speeds. IPMI also supports automatic event notification, remote shutdown and restart, and dynamic power allocation to individual AdvancedMC modules. This supports the hot-swap capability of the MicroTCA architecture. As mentioned earlier, the MCH module manages the unit's IPMI bus. Figure 3 shows a functional block diagram of the IPMI bus in a MicroTCA chassis.

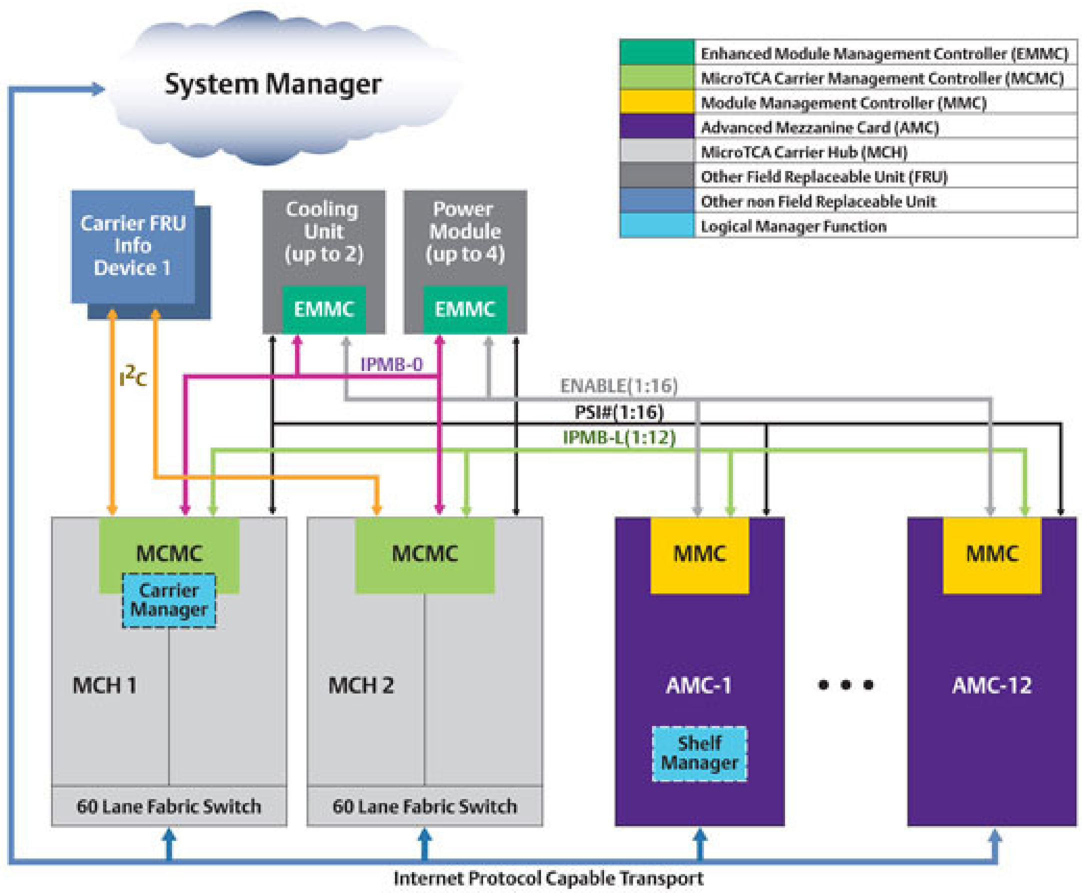

FIGURE 3: The IPMI bus

MicroTCA chassis are manufactured in various shapes and sizes to address a wide range of applications. Small/rugged enclosures, desktop cubes, and IEA 19" rack mount chassis varying from 1U to 5U are a few examples of available chassis types.

Figure 4 shows a typical 2U rackmount chassis configuration with redundant power supplies, redundant controllers, and redundant cooling units.

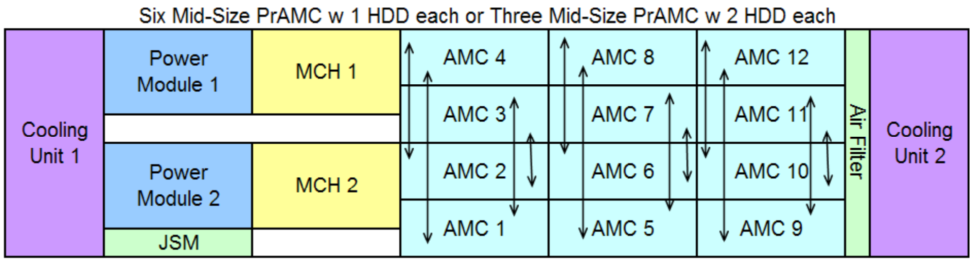

FIGURE 4: Example of a 2U Chassis Configuration

A partial goal, for the purposes of this paper, was to determine if modules from multiple manufacturers could interoperate within the same chassis, and to determine if these modules could exchange error-free data with modules from other manufacturers in a separate chassis on the network. By using a variety of manufacturers during our testing, we can prove the interoperability of multiple manufacturers in a MicroTCA system.

System number 1 was comprised of a rackmount chassis from Vendor A, an MCH and ATM module from Vendor B, a processor module from Vendor C, and a TMoIP module from Vendor D. System number 2 was comprised of a desktop chassis, processor module, and MCH module from Vendor E, an ATM module from Vendor F, and a TMoIP module from Vendor D. Figure 4 shows a block diagram of the test configuration.

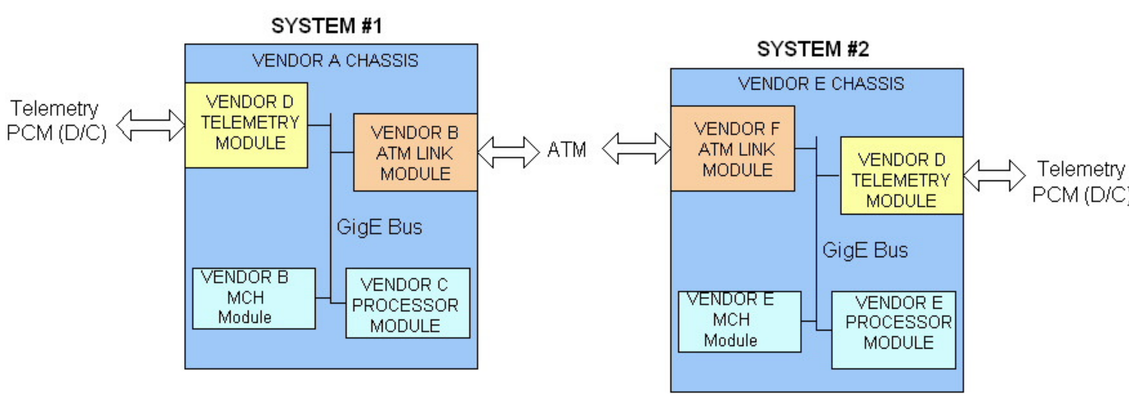

FIGURE 4: TEST CONFIGURATION

A bit error rate tester was used to create a pseudo-random PCM stream. This bit stream was inserted into the Telemetry module in System #1. The telemetry module converted the PCM stream to IP packets per the RCC TMoIP standard 218-08 and streamed the packets onto the GigE bus on the chassis backplane. These IP packets were then directed to the ATM Link Module and sent over an ATM network to System #2 where the ATM cells were stripped, and the IP packets were put onto the GigE bus. The Telemetry Module received these IP packets and converted the stream back to a PCM output.

Several long-duration tests were run as the bit rate of the PCM simulator was varied between 100 kbps to 30 Mbps with no errors. These same tests were run again, but with the simulated PCM data inserted into Systems #2 and recreated by System #1. These tests also ran without error. The results of this testing shows that error-free telemetry data can be transported between two MicroTCA systems across an ATM network.

Additional tests were run where the ATM modules were removed and the MicroTCA units were linked via an Ethernet network. The same bit error tests were conducted with error free results. Telemetry data throughput latency was optimized on both configurations and was measured at 3 msec.

4. CONCLUSION

If the DoD test ranges would like to break the monopolies created when settling for proprietary architectures, and reduce the risk that their systems may quickly become obsolete, an open standard exists that can address all of the needs of the telemetry community. MicroTCA is an existing commercial off-the-shelf (COTS) architecture that is proven to be a viable candidate for the ideal Networked Telemetry System.

There are currently several dozen manufacturers that already offer a variety of MicroTCA chassis and data I/O modules in the standard AMC format. Asynchronous modules, avionics bus modules, SONET modules, ATM link modules, even synchronous PCM telemetry modules that adhere to the RCC TMoIP standard are available.

There are also multiple manufacturers that currently offer a large variety of storage and processor modules in the AMC format. One could speculate that the MicroTCA format may have the potential to record telemetry in an RCC standard format. It may also provide the capability for real-time and/or post-mission data processing. This potential is recommended for further investigation.

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