MTCA.4 TUTORIAL BASICS
INTRODUCTION IN XTCA

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AGENDA

• What is xTCA?
• Specifications Overview
• ATCA Features
• AMC Features
• MTCA Family
• MTCA.0 Features
• MTCA.4
  • Initial Requirements
  • Mechanical Features
  • Module sizes
  • Management extensions compared to MTCA.0
  • Keying
  • Hot Swap Transition States
• Backplane
• Cooling
• Redundancy
WHO WE ARE

• Leader in providing high-quality protection solutions for a wide variety of electronic design challenge

• Large selection of standard 19” products, plus the broadest array of modification options and customization capabilities

• Offering world-leading electronic packaging components and systems – within 19” and beyond
WHAT IS xTCA?

- ATCA: Advanced Telecom Computing Architecture
- AMC: Advanced Mezzanine Card
- MTCA: Micro Telecom Computing Architecture

xTCA connects ATCA, AMC, and MTCA, representing their relationships and integration in advanced telecom computing architecture.
OVERVIEW

- Introduced in 2002
- Sponsored by the PCI Industrial Computer Manufacturers Group (PICMG)
- Specification initially targeted to the Telco Industry
- HA features of interest to many other “up time” critical systems!
- System Availability 99.999% (~5 min/yr)!
- Management, monitoring and control!
- Port data rate up to 100 Gb/s (4 x 25Gb/s)
- System throughput to 24 Tb/s (16 Slot, full mesh)!
ATCA SPECIFICATION FAMILY

PICMG 3.0
AdvancedTCA Base Specification

PICMG 3.1
Ethernet/Fibre Channel Over PICMG Rev. 3.0

PICMG 3.2
InfiniBand Over PICMG 3.0

PICMG 3.3
StarFabric/Advanced Switching for AdvancedTCA Systems

PICMG 3.4
PCI Express and Advanced Switching for AdvancedTCA Systems

PICMG 3.5
Serial RapidIO for AdvancedTCA Systems

PICMG 3.8
AdvancedTCA Rear Transition Module Zone 3A

IRTM.0
Intelligent Rear Transition Module (IRTM) Base

AMC.0
Advanced Mezzanine Card Base Specification
ATCA CRATE ELEMENTS

Front View

- Redundant Fan Tray (Push)
- Backplane
- Dual redundant Shelf Managers

Rear View

- Redundant Fan Tray (Pull)
- Power Entry Module (PEM)
- Alarm Board

Board size and connectors

- Front board size 8U x 280 mm
- Rear board (RTM) size 8U x 70 mm
  Connects directly to front board
- Board width 6HP (1.2”)
- Alignment/Key pins
- Zone 1: Management and Power
- Zone 2: Base Interface and Fabric Interface
- Zone 3: Interface to RTM
Zone 2 Backplane Interfaces

- **Base Interface**
  - 10/100/1000 BASE-T Ethernet
  - Always Dual Star topology

- **Fabric Interface**
  - Star topology
  - Mesh topology

- **Clock Interface**
  - Three dedicated clock interfaces

- **Update Channel**
  - Direct connection between two slots
ATCA Shelf Management purpose

- Monitor & control low-level aspects of ATCA boards and other Field Replaceable Units within a shelf
- Watch over basic health of the shelf, report anomalies, take corrective action when needed
- Retrieve inventory information & sensor readings
- Receive event reports and failure notifications from boards and other intelligent FRUs
- Manage power, cooling & interconnect resources in the shelf (electronic keying)
- Management Protocol IPMI (I2C-bus on backplane)
ATCA MANAGEMENT

- Dedicated Shelf Management Controller (ShMC)
- ATCA Boards with IPMC
- Protocol IPMI (Physical layer I²C-Bus)
- Intelligent and Managed FRUs
- Bused or Radial IPMB
AMC MODULES

- Initially developed as function extension for ATCA Boards
- Fully integrated into the ATCA IPMI management structure
- Plugged into a so called ATCA Carrier
- Hot Swap capability
AMC MODULES

Carrier IPMC represents the MMC on the AMC as a FRU to the Shelf Manager

ShMC
- Manages Cooling for Carriers
- Provides interface to outside world (RMCP / CLI / HTTP)
- Event Log and Sensor repository

IPMC / Carrier Manager
- Management Interface to the ShMC for the Carrier Board
- Manages the AMC Modules
  - Power
  - E-Keying
  - Sensors
AMC MODULES

AMC Module Sizes

- **Single**: 73.8 mm
- **Compact**: 73.8 mm = 3 HP
- **Mid-size**: 73.8 mm = 4 HP
- **Full-size**: 98.8 mm = 6 HP
- **Double**: 148.8 mm
AMC MODULES

- Media Processing AMC
- Line Interface module
- RF interface card for software defined radio
- Processor AMC
- Processor AMC
- Integrated AMC based on TI DSP + Xilinx FPGA
MTCA

Micro Telecom Computing Architecture
MicroTCA® | FEATURES

- Similar feature set as ATCA
  - Extremely high data transmission, 10 Gb/s per port & 40 Gb/s per link
  - AdvancedMC interchangeable between AdvancedTCA and MicroTCA
  - Protocols: 10GBaseT Ethernet, PCI e, Serial Rapid I/O, SAS, and S-ATA.
  - Fully redundant or non-redundant systems available
  - Hot-swap capability ensures uninterrupted operation
  - Shelf and carrier management
    - Allow administration and monitoring of system resources
    - Board protection via electronic coding (e-keying)
  - Small form factor (compared to ATCA, CPCI or VME)
MTCA - TERMS AND ACRONYMS

- **MCH**  MicroTCA Carrier Hub
  - This is a complete module for the system management and Ethernet hub

- **MCMC**  MicroTCA Carrier Management Controller
  - This is the physical IPMI controller on the MCH

- **MMC**  Module Management Controller
  - This is the physical IPMI controller on an AMC

- **EMMC**  Enhanced MicroTCA Carrier Management Controller
  - This is the physical IPMI controller on a Cooling Unit and on Power Module

- **IPMB-0**  Intelligent Platform Management Bus 0
  - Logical IPMB, physically divided into redundant IPMB-A and IPMB-B

- **IPMB-L**  IPMB-Local
  - IPMI link between MCH and AMCs
MTCA.0
The basic idea of MTCA is to have a shelf that contains just AMC modules.

AMCs are interchangeable between ATCA and MTCA.

Backplane directly accepts AMC modules.

The infrastructure of an ATCA Carrier was adapted into the MTCA shelf (power, management, switching).

No rear I/O, power input, and all outputs to the front.
MTCA.0

- As MicroTCA does not use a Carrier board, the power, management, clock distribution and switching functionality must be realized onto another device

- New Module: MCH (MTCA Carrier Hub)
  - IPMI management
  - clock distribution / generation
  - Switching functionality
  - JTAG slave / master
  - Redundant MCHs

- New Module: Power Module
  - 12V Payload Power
  - 3.3V Management Power
  - Redundant power modules

- Special MTCA Shelf Slots for these new modules
ATCA Carrier Board

AMC

MMC

MMC

Zone 1

Zone 2

Zone 3

Power

Carrier IPMC

Switching

Clock distribution

Current Limit

Current Limit
MTCA.0 - BLOCKDIAGRAM

Defined in PICMG® MicroTCA.0.

- **MCH** MicroTCA Carrier Hub
  1. Power & Cooling
  2. Electronic Keying & Hot-Swap for AMCs
  3. External management interfaces (over Terminal or Network)

- **MCMC** MicroTCA Carrier Management Controller. This is the physical IPMI controller on the MCH

- **MMC** Module Management Controller. This is the physical IPMI controller on an AMC

- **EMMC** Enhanced Module Management Controller. This is the physical IPMI controller on a Cooling Unit and on Power Module
MTCA.4
MTCA.4

Why were extensions needed to the existing MicroTCA specifications?

- No Rear Transition Module (RTM) defined for MicroTCA
  - Physics applications typically require a large number of I/O cables. It makes sense to connect them to the rear of the chassis

- Special clock and trigger topology
  - MicroTCA.0 specifies 3 Clocks and AMC.0 R2.0 specifies 4 Telecom and 1 Fabric Clock on the AMC Module. Physics applications typically need additional Clocks and Triggers

- Sophisticated requirements for the clock and trigger accuracy
  - MicroTCA / AMC defines typical telecom clock signals corresponding to PCIe values. Trigger signals are not specified
MTCA.4

Requirements for mechanics and sizes

- AMC Module size: Double, Mid-size
  - Allows for the max number of 12 AMCs in a 19” wide shelf

- Large MicroRTM real estate
  - MicroRTM size approximately the size of the AMC (doubles depth of existing uTCA chassis)

- Use front panel mechanics based on Rugged MicroTCA (MTCA.1)
  - Need to mechanically attach a module to avoid it being pushed-out by the corresponding module
  - Use Rugged MicroTCA retention device

- Reuse existing AMC front panels for the MicroRTM
- Allowing mounting of mezzanine modules on the rear of the backplane
- Optional zone 3 backplane
Features of MTCA.4 shelf with MicroRTM, side view

- Safety keying, 8 positions
- 3-pair ZD connector (2 x 30 diff. pairs)
- μRTM handle, is at the top of the μRTM (μRTM front panel appears up side down)
- AMC card edge connector
- Space for mounting mezzanine boards
  Could be used for clock and trigger distribution
- Retention device (defined in Rugged MicroTCA spec.)
- Retention device (defined in Rugged MicroTCA spec.)
MTCA.4

Alignment and Keying

- mechanical keying prevents a module from being inserted which is not electrically compatible and could cause damage

- Eight keying positions are implemented that define the electrical interface

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<th>Rotation in degrees</th>
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<th>View into rear of µRTM Post</th>
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MTCA.4

Module Sizes

AMC Side 2

μRTM Side 2

Double Wide

(180.85 +/- 0.4) (Rugged uTCA Spec. Figure 2-7)

188.15 +/- 0.4
Management defined in AMC.0 / MTCA.0

- **IPMB-L**
  - Connects the MCMC on the MCH to the MMC on the AMC Modules
  - Radial architecture

- **IPMB-0**
  - Connects the MCMC on the MCH to the EMMC on the PM and CU
  - Bused architecture
Management extensions in MTCA.4

- **IPMB-L**
  - Connects the MCMC on the MCH to the MMC on the AMC Modules
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- **IPMB-0**
  - Connects the MCMC on the MCH to the EMMC on the PM and CU
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- **I2C-Bus**
  - Connects the AMC to the μRTM
  - The μRTM is treated as managed FRU of the AMC
MicroRTM Management

- A management interface is defined on the lower zone 3 connector
- Management and power signals:
  - μRTM-MP: Management Power for the EEPROM, Temp. Sensor and I/O Expander
  - μRTM-PWR: Payload power for the RTM
  - μRTM-PS#: RTM Presence signal, grounded on the RTM
  - μRTM-SCL/SDR: I²C bus coming from the AMC MMC going to the RTM
POWERING UP A MTCA SHELF

- MCH
- CU
- Operational
- IPMB-0
- PM
- 12V
- Operational
- Operational
POWERING UP A MTCA SHELF
MTCA.4 – HOT SWAP STATES

- **M0**: Board not installed
  - Activation in Progress (M3)
  - Board Inactive (M1)
  - Deactivation in Progress (M6)

- **M1**: Board Inactive
  - LED on
  - Handle closed

- **M2**: Activation Request
  - LED long blink

- **M3**: Activation in Progress
  - LED off
  - Activation command

- **M4**: Board Active
  - LED off
  - Handle opened

- **M5**: Deactivation Request
  - LED short blink

- **M6**: Deactivation in Progress
  - LED short blink

- **M7**: Communication Lost
  - LED off

- **Activation complete**
  - Fringe (simplified)

- **Deactivation complete**
MTCA.4 – 12-SLOT BACKPLANE

- Common Options
  - MCH1 Fabric [A] to AMC Port 0
  - MCH1 Fabric [B] to AMC Port 2
  - MCH2 Fabric [A] to AMC Port 1
  - MCH2 Fabric [B] to AMC Port 3
  - Fat Pipe MCH1 Fabric [D:3] to AMC Port [4:7]
  - Extend Fat Pipe MCH2 Fabric [D:3] to AMC Port [8:11]

- Clocks
  - MCH1 CLK1 to AMC TCLKA
  - MCH1 CLK2B to MCH1 CLK2 (MTCA.0 Figure 6-6)
  - MCH2 CLK1/LHC clock to AMC PCLKA
  - AMC TCLKB to MCH1 CLK2 (MTCA.0 Figure 5-8)

- 4 x PCIe
- Point-to-Point Links
- 8 x M-LVDS: Trigger
MTCA.4

Front board and MicroRTM power distribution

- The total power for a slot (front board and RTM) is supplied through the front board AMC connector.
- The MicroRTM power is supplied from the front board through the Zone 3 connectors.
- Total available power for a slot is 80 Watts, the MicroRTM power is limited to 30 Watts.
- The power required by the MicroRTM is subtracted from the power for the front board.

![Diagram showing power distribution](attachment:power_distribution_diagram.png)
MTCA.4 – COOLING CONCEPTS

Vertical boards

The cooling concept depends on the installation situation of the chassis:
• Front-to-rear air flow
• Side-to-side air flow
• Bottom-to-top air flow
• Front-to-side air flow

Fan configuration:
• Push
• Pull
• Push-pull
MTCA.4 – COOLING CONCEPTS

Horizontal boards

- Push configuration
  Side-to-side

- Pull configuration
  Front-to-back
Air flow measurements in MTCA.4 Shelves

• One of the most critical issues in a shelf is cooling of the installed modules

• A reliable method to define the cooling capability of a shelf is to measure the volumetric air flow in m$^3$/h or cfm

• Measured Air flow values:
  ➢ Bulk air flow value for the total shelf air flow
  ➢ Individual air flow per slot

• Cooling capacity can be calculated based on the Air Flow and desired temperature differential between air intake and air exhaust
MTCA.4

- Bulk air flow measurements in wind tunnel:
- Per slot air flow measured with air flow measurement boards and Flow Impedance Boards (similar to cp-ta in ATCA)
Test results:
Bulk air flow measured in wind tunnel = 635 m$^3$/h  
Sum of per slot air flow (front and rear) = 644 m$^3$/h

Cooling capability approximation: Power = Air Flow * $\Delta$T / 3.3
AMC slot 1: 24.3 m$^3$/h => cooling capability (at $\Delta$T=12k) ~ 88 Watts
RTM slot 7: 12.1 m$^3$/h => cooling capability (at $\Delta$T=12k) ~ 44 Watts
How can MTCA.4 improve the reliability of the system?

• Prediction of failures (e.g. a fan does normally not fail instantly)

• Monitoring of every temperature sensor on every module and FRU

• Isolation of faulty modules (e.g. powering down over-heated modules)

• Power management

• Redundancy
Redundancy

- For high availability applications all modules are redundant:
  - 2 x MCH
  - 4 x Power Module
  - 2 x Cooling Unit
  - IPMB-0:
    One logical bus divided into two physical busses: IPMB-A and IPMB-B
MCH Redundancy

- Two MCH: One is Master, One is Redundant
- Redundant chassis / shelf FRU Information SEEPROM
- Redundancy Interface between the two MCH
- Redundancy defined in chassis / shelf FRU information
Power Module Redundancy

- Up to 4 Power Modules per chassis
- Redundancy mode defined in shelf FRU file
- Individual power channel to each module and FRU

```
PM 1: Primary

Primary Power
 Pass FET
ON
 ORing FET
ON
 Primary Control

PM 2: Redundant

Redundant Power
 ORing FET
OFF
 Pass FET
ON
 Redundant Control

+12V Payload Power

+ 3.3V Management Power
```
Cooling Unit Redundancy

- Redundant Cooling Units in push-pull configuration
- Scenario 1: fan failure
- Scenario 2: Cooling Unit replacement
MTCA.4 - REDUNDANCY

IPMB redundancy

- Individual IPMB-L to each AMC
- Redundant logical IPMB-0 to PMs and CUs
MTCA.4 Chassis types

Various different MTCA.4 chassis available now:
- Laboratory use
- Fully redundant
- Compact sizes
- Small form factors (MTCA.0)
MTCA.4

LLRF Backplane

Definition of a RTM Auxiliary Backplane
- Based on the LLRF backplane developed at DESY
- Optional connector usage
MTCA.4

Standardization continues: AMC Covers

Protective mechanical cover for AMC and RTM modules
- Protective cover to mechanically protect components
- For Side A and Side B
- Designed for Double Mid- and Double Full Size modules
PICMG MTCA-IW → Interoperability Workshop

- Module and shelf manufacturers test the interoperability of their products
- Test matrix defines „who tests with who“
- Last TCA-IW was held at Vadatech / USA in October 2014.
  - MTCA.4 Chassis manufacturers
  - MTCA.4 AMC manufacturers
  - MTCA.4 PM manufacturers
  - MTCA.4 MCH manufacturers
THANK YOU

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