Next Generation Electronics based on µTCA for Beam-Diagnostics at FLASH and XFEL

Patrick Gessler, DESY/XFEL
Motivation and Outline

- Introduction: DESY and the XFEL
- Features of the new μTCA standard (MTCA.4)
- Management features
- Required components for Diagnostics
About 200 µTCA crates

Data acquisition from DC to 3.9 GHz

High speed communication
  - PCIe to I/O
  - Ethernet 3 km

Has to operate 24/7
  - Some redundancy

Well defined management
  - A must for large systems and for high availability

Hot-swap
  - Safe against hardware damage and software crashes
The XFEL will be Based on µTCA

- Scaleable modern architecture
  - From 5 slot single … 12 slot double size
- High availability
  - Redundant power and fan optional
  - Well defined management
- Differential links only: high analog signal processing quality

\[
A = \frac{E[\text{Uptime}]}{E[\text{Uptime}] + E[\text{Downtime}]} 
\]
Results of the µTCA Evaluation

- We did it the hard way:
  - Crates, CPUs, IO and MCH from different vendors
- Management of crates is well defined
  - Dynamic module and crate info gives all relevant info
- Fast data transfers (>400MB/s on 4 lanes PCIe)
- Hot-swap (implemented and tested with Solaris and Linux)
- Good decoupling of modules on the backplane
- Good analog performance
- µTCA standard requires a few additions
  - The specs are made for telco, customized solutions, we want COTS → xTCA for Physics @ PICMG

→ xTCA platform is a good basis for large installations
MTCA.4 was developed by

- Science
  - SLAC, California
  - FNAL, Chicago
  - IHEP, Beijing
  - IPFN, Lisboa
  - ITER, Cadarache
  - DESY, Hamburg

- 38 corporations
  - Crate, board, system and connector manufactures

http://www.picmg.org/
Cables from rear e.g. SMA 1.3GHz

μRTM:
I/O adapter, Application specific signal conditioning and cable adapters

AMC connector:
Ethernet and PCIe, Clock and Trigger

Standard front AMC:
FPGA with high speed data links,

Connector:
Analog or digital signals, power and management
Clock, Trigger and Interlock Signals

2 radial clocks per AMC, Low jitter, configurable direction

8 bussed M-LVDS lines, For triggers, clocks and interlocks
MTCA.4: Available Shelves

12 Slot

6 Slot

Elma

Schroff
μTCA Carrier Hub (MCH)

- Management
  - Cooling
  - Power supply
  - Hot-swap
  - Electronic keying
  - Remote access
  - Alarms
- PCIe switching
- Gb Ethernet switching
- Clock distribution
Analog-to-Digital Conversion

- Signal Conversion
- Splitting
- Integration
- Filtering

- Clock shifting
- Signal digitizing
- Processing
- Controlling
MTCA.4 µRTM: 53 diff. Lines for general I/O applications, Standard management

FMC (Vita 57) Slot: Additional I/O
Low Cost Double FMC Board

- Low cost FPGA
- Two or double FMC slots
- Possible Applications
  - ADC
  - DAC
  - DSP
  - I/O
- High performance FPGA
- Many high speed inputs and outputs
  - SPF on the front
  - On the RTM connector
  - On the AMC connector
- Dedicated DSP (Tiger Sharc)
- Applications
  - Data processing
  - Data reduction
  - Real time feedback
A Timing System to Sync the Overall Facility

Goal:
Stability of <= 5ps RMS

Prototype receiver / transmitter with MTCA.4 clock and trigger distribution

> 3 km
Central Processing Unit (CPU)

Control System, PC, Web

CPU within the Crate

AMCs
ADC, DAC, IO, Processing

Ethernet

PCIe / Ethernet
MTCA.4 Specification will be published in June ‘11
- Is fully compatible to AMC and MicroTCA standards
- Provides extensions for
  - Rear I/O with adequate space for I/O
  - Timing and synchronization
- Prototypes of required hardware and crates are available
- Excellent analog performance has been demonstrated
- Well defined (remote) management supported

→ $\mu$TCA is a good platform for large installations in industry and science
Thank you for your attention
## µTCA Form Factors

<table>
<thead>
<tr>
<th></th>
<th>Compact-Size (3HP)</th>
<th>Mid-Size (4HP)</th>
<th>Full-Size (6HP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>73.8x13.88x181.5mm</td>
<td>73.8x18.96x181.5mm</td>
<td>73.8x28.95x181.5mm</td>
</tr>
<tr>
<td>Double</td>
<td>148.8x13.88x181.5mm</td>
<td>148.8x18.96x181.5mm</td>
<td>148.8x28.95x181.5mm</td>
</tr>
</tbody>
</table>

MTCA.4 Extension
12 Slot MTCA.4 Backplane

Port | Slot: #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12
-----|---------|----|----|----|----|----|----|----|----|-----|-----|-----
Common | 1GbE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Fat Pipe | PCIe or SRIo | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
Ext Fat Pipe | 1GbE/SRIo | 16 |
Extended Options | Point-2-point links | 17 | 18 | 19 | 20 |
Clocks | C1k 1 | | | | | | | | 8 * M-LVDS: Trigger
| C1k 2 | | | | | 8 * M-LVDS: Trigger
| C1k 3 | | | | | 8 * M-LVDS: Trigger

Point-2-Point: App Links

17th May 2011 | DIPAC2011 | Patrick Gessler
Management Integration

jddd

JAVA Application

DOOCS X:GA IPMI Server

IPMI