MTCA.4 & PXI Express
Debriefing of Proof-of-Concept projects

Controls Coordination Committee (CO³)

Geneva, 26 April 2018
Agenda

- MTCA.4 PoC
  - Project status
  - MTCA.4 equipment
  - CO Services for MTCA.4
  - Where to use the platform?

- PXIe status

- Summary
MTCA.4 PoC status

- **April 2017**: BE-RF and BE-CO decide to co-develop a proof of concept RF cavity controller in MTCA.4.
- **August 2017**: MTCA.4 equipment arrived (4 systems). Development of HDL & low-level software started.
- **February 2018**: first version of RF firmware implemented on the test MTCA.4 system.
- **March 2018**: SPS LLRF review decision: go for MTCA.4.
- No significant technical issues observed during the PoC.
- Good collaboration with the hardware vendors (NAT and Struck). Less good with DESY.
- BE-CO and BE-RF working **together** on HDL and low-level software development.
MTCA.4 Equipment

- Crate: 12 slots, made by Schroff/Pentair.
- CPU: Xeon E3, by N.A.T.
- MCH: provides crate management and PCIe/Ethernet backplane connectivity. Made by N.A.T.
- RF Backplane: standardized additional backplane for low-noise RF signals (e.g. clocks).
MTCA.4 Equipment

**SIS8300-KU board:**
- Flexible COTS platform for RF feedback systems development.
- 10 16-bit ADC channels @ 125 MHz
- 1x 16-bit vector DAC @ 500 MHz
- Powerful FPGA (Kintex Ultrascale 7KU35)
- 512 MiB DDR4 memory
- Built-in White Rabbit support.

**DS8VM1 RTM Module:**
- Analog front-end for the ADCs
- Vector modulator/upconverter for the DACs.
CO Services for MTCA.4

- **Standard platform services, just like VME:**
  - CC7 support
  - remote reset & power-cycle
  - remote console
  - monitoring

- **Stock of standard modules (crates, CPU+MCH, timing).**

- **Procurement of standard MTCA.4 components:**
  - CO will take care of specification (together with the Eqp Groups), market survey and tendering process.
  - Ensure stable contracts for delivery of equipment in the coming years.
  - Reliable partnership with the industry.

- **Benefit from EP department experience with MTCA.4**

- **Provide design expertise:**
  - FPGA and MMC design aid and troubleshooting.
Example: RF FPGA

Xilinx XDMA PCI Express Core

AXI Crossbar

Xilinx DDR4 controller

PCIE Gen3 x4

DMA

MMIO

Control Regs

DDR Memory

System Top Level

WR Core

System MCU

ADC interface

DAC interface

User Top Level

AXI/WB to Cheburashka bridge

The LLRF

SPI/I2C (AD9510, AD9268, etc).

ADC/DAC Raw data

AXI4 Full, 512 bits, 125 MHz

AXI4 Lite, 32 bits, 62.5 MHz
**Where to use MTCA.4?**

**MTCA.4 provides a lot of features but its complex and currently not cheap**

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Digital feedback systems (LLRF)</td>
<td>Simple digital I/O</td>
</tr>
<tr>
<td>High-end signal acquisition and instrumentation</td>
<td>Interfaces (e.g. fieldbuses)</td>
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<tr>
<td>Multi-gigabit communication between the boards</td>
<td>Low to mid-range signal acquisition</td>
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<td>Ultra-low jitter timing</td>
<td>Motion control</td>
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<td></td>
<td>Sensors</td>
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* cost of a 12-slot Schroff crate with NAT MCH, CPU and PS: 8588 EUR.
MTCA.4 PoC: conclusions

MTCA.4 PoC going well.

- New project within BE-CO to provide full set of services for MTCA.4:
  - See next presentation by Marc.

- New model of collaboration (CO supporting HDL and software developers).
PXIe PoC status

- 2 installations operational in the LHC since May 2017.
- System working well, but...
  - Only simple acquisition with Spectrum M4i digitizers.
  - No PXIe-specific features in use (e.g. triggers).
Negotiations with NI since 2016.

Still no crate that meets CERN requirements available:
- Field-replaceable PSU & fans
- AMT available only on few CPU models

Extremely expensive for the features it provides:
- 8.5 k$ for a basic PXIe crate and a mid-range CPU*.
- Our recent deal with Microsoft (and others) proves discounts don’t last forever...

NI refusing to provide open source device drivers:
- Countless meetings with NI representatives brought promises, but no deliverables.
- Drivers that are of most interest to CERN are scheduled as the last (e.g. NIScope at the end of 2019).

* PXIe-1082 crate (4065 $) and PXIe-8840 CPU (4649 $)
BE-CO cannot recommend PXIe as an operational platform as it is right now.

- Similar price as MTCA.4 for less features
- No crate designed for field use
- Poor driver support for NI devices
- Only one CPU and crate vendor available for CERN (NI):
  - ADLink not in a member state
  - Bad support experience with Keysight

... but this does not mean we are done with PXI(e)!
Summary

• MTCA.4 PoC with RF well on track.
  • BE-CO will provide official support for MTCA.4.
  • Tests in BA3 in summer/autumn 2018.
  • Looking for more MTCA.4 pilot projects.
• PXIe cannot be recommended in its current state.
  • Too expensive for the features it provides.
  • Single vendor (NI). Difficult collaboration.
  • Design of a rugged PXIe crate is a possible long term solution.