EUROPEAN SPALLATION SOURCE

ESS Controls Infrastructure

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Overview

- Hardware platform(s)
  - High-speed digital platform
  - Middle range I/O
  - Industrial I/O
- Timing system
- Software (EPICS)

Scope of hardware platforms

- Control systems have a lot of interfaces
  - Need to cater for a spectrum of I/O requirements
    - Fast, real-time signal processing
      - State-of-the-art technology, evolving fast
      - FPGA-based processing
      - MHz to GHz range of signal acquisition
    - Middle-range I/O
      - requires synchronization, kHz range I/O
    - Non-real time industrial I/O
      - Typically PLC-based
    - Off-the-shelf devices
      - Serial, Ethernet or other fieldbus devices
- No single platform can cover this cost-efficiently!

High-speed Digital Platform

- Performance requirements (very shortly)
  - Support 14 Hz operation
    - Good integration with timing
  - Acquisition (ADC sampling) at 88 MSPS or faster
    - 2.86 ms long pulses: a lot of data to be handled
  - Local pre-processing of data
  - Interfaces to machine protection/interlock
  - Post-mortem abilities
- In fact, any (packaging/bus) platform could provide this!
  - The real questions are elsewhere:
    - Maintainability
    - Development and long-term sustainability
    - Collaborations and support for IKC partners

High-speed Digital Platform – the box

- Today, there is no clear single choice
  - cPCI, VME, custom (aka “pizza”) box, MTCA.4,...?
- Serial links have overtaken parallel buses
  - Intelligence is in the interfaces and protocols
  - The “box” supplies infrastructure (power, cooling, monitoring, connectivity, some convenience features)
- Take a proven solution or go for something new?
  - Several labs are looking at MTCA.4
    - DESY (main promoter), SLAC, many others
    - ESS prototyping and development on MTCA.4
  - Not much existing hardware off-the-shelf

MTCA.4 structure

- xTCA is a telecommunication standard
  - Focus on teleecom needs
    - Bulk data transfer, different protocols
    - Platform management features
      - Targeted for (telecom) high availability
      - Sophisticated (=complicated)
  - MTCA.4 is called “uTCA for Physics”
    - Add Rear Transition Modules (RTM) for I/O
    - High-precision clock distribution
    - “interlock” lines on backplane
      - Bussed (not very useful for protection ☹)

High-speed Digital Platform – blocks

- FMC (FPGA Mezzanine Card), VITA-57 standard
  - Separate analog (application-specific) and digital parts with a defined interface
    - One digital board can be used for several purposes
      - Reduce hardware stock complexity
    - Re-use of firmware libraries, software, integration
  - Modularization at the level of the major investment
    - Firmware, software, operational procedures
    - Separation of work (defined interfaces)

High-speed Digital Platform - framework

- Setting up a collaboration with PSI (ESS partner lab)
  - Framework for digital high-speed applications
    - Combination of powerful FPGA and C
  - Done with industry (small company) collaboration
    - Evform factor is different – majority of effort is in the infrastructure for applications
    - Used in production (PSI LLRF, diagnostics, etc.)
  - This would be an overkill for the needs and not necessarily even suitable. To be seen
    - Advantage of timing integration exists, though

MTCA.4 and beam interlocks

- Nothing equivalent to CERN BIS exists today (As far as I know)
  - Would need to be developed from scratch
- Does BIS need to be on MTCA?
  - Control system integration (could be solved otherwise)
  - Many user systems (instrumentation) will be on MTCA
    - These need an interface – to be defined

ESS Timing system

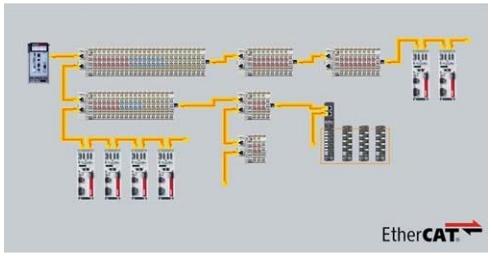
- Based on hardware by Micro-Research Finland
  - Originally developed for PSI/Swiss Light Source
  - Used in many accelarators (DLS, LCLS,...)
  - Lots of community development (software, open firmware, applications)
  - Basic capabilities:
    - High precision trigger distribution
    - Real-time data broadcast (beam info, etc.)
    - Sequencing
    - Synchronous timestamp delivery
  - Doing many of the same things than the CERN system but in a slightly different way.

EPICS and low-level software

- ESS uses EPICS as the control system platform
  - Running on (embedded) Linux
  - Interfacing different devices is (relatively) easy
  - Rather sophisticated things can be implemented low-level (not to be relied on, though)
  - Has its own alarm and limits monitoring system
    - Can be used to develop “soft interlocks”
      - (this term has caused a lot of confusion)
  - I do not think EPICS vs. FESA is a big issue for collaboration in machine protection.

Middle-range I/O

- High-end platform is expensive and centralized
  - Use only where needed
- Some applications still need time synchronization
  - Especially in a pulsed machine!
  - PLCs are not ideal for this (asynchronous cycle times)
- EtherCAT is a good solution for this range
  - Uses Ethernet cabling, special protocol
  - Can run on a PC or a “hard” IOC
  - Loop times of several kHz possible
  - Distributed I/O (reduce cabling)
  - Cost effective
  - Many I/O modules, several manufacturers
- Gaining popularity in the EPICS community



Industrial I/O

- PLC is the standard choice for most industrial-type I/O
  - High reliability
  - Widely known and deployed in partner labs and industries
  - A huge selection of I/O modules available
- Ideally, select one manufacturer
  - Reduce development and maintenance costs
    - One skillset, reduced stock of spares
  - Select a manufacturer with domain expertise
    - Local support for IKC partners
  - Procure via an open call for tender
    - Not quite straightforward, though – but in progress

“Other” I/O

- There is still a large number of devices not covered yet
  - Serial devices
    - Use MOXA – seems to be almost de-facto standard
  - Ethernet-based devices
    - Ethernet as a fieldbus, use StreamDevice & ASYN
  - Cameras
    - GigE, 10GBE, CameraLink(HS)
      - Very much provider-dependent – take what the company gives
    - EPICS AreaDetector supports a large device base
  - Motion control
    - Working together with our NSS colleagues

Summary

- Decided to use MTCA.4 for instrumentation and LLRF
  - There is a lot of work to be done
  - Nothing (useful for ESS) in BIS area exists on MTCA – as far as I know
- Listening to the talks it became obvious that
  - A lot of excellent thinking and experience exists at CERN
  - Collaborating in some form would be a big advantage for ESS
    - How to make this mutually attractive?

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Questions?

Reserve slides

High-speed Digital Platform

- What to take, then?
  - Decide on **one** platform (and concentrate on it)
  - Certain level of know-how on MTCA.4 exists
    - With platform management (pains)
    - Single CPU configuration
    - “Front” card + RTM configuration
- Work to be done on the platform
  - Platform alone does not provide any functionality
  - Systems and processes have to be built around
    - Here lies the major investment!
  - We have some components developed but
    - Deployment will bring up many issues
    - Systems need to be maintained for a long time

High-speed Digital Platform – and beyond

- Lifetime issues
  - ESS project timespan > 10 years
    - Obsolecense issues will arise during the project
    - Need to be ready for change!
  - Biggest cost factor is in integration
    - Software, firmware, maintenance processes
    - How could that be modularized?
- Development of a full lifecycle system is costly
  - Has somebody addressed the deployment issues?
  - How to do gradual upgrades?
  - How to secure maintainability?
- Deciding the packaging standard is not enough
  - A more comprehensive framework is needed