Status and future of beamline control software at ESRF

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Beamline Control Unit (former BLISS)
Support and Development of beamline control software
29 ESRF and 12 CRG beamlines, 6 Laboratories
16 people
Outline

• Beamline control today:
  • Software architecture
  • Continuous scans
  • Fast 2D detectors
  • Graphical Interfaces

• Evolution
• Conclusion
Software overview

- USERS
- Beamline GUI / Online display
- SPEC
- TANGO / TANGO
- Linux / Windows drivers
- HARDWARE
Hardware overview:

Network

- Industrial PC / Linux
- VME + Bus Coupler
- ICEPAP motor controller
- Linux workstation
- Detectors
TACO / TANGO
Control of distributed hardware

**TACO**
- Developed at ESRF
- Obj. C / RPC
- Client and server API in C/python/matlab/labview/…
- Only commands

*Widely used on beamlines:*
- ~100 different servers
- 7000+ devices exported

**TANGO**
- Collaboration ESRF, Elettra, Soleil, ALBA, DESY
- C++ / CORBA
- Client and server API in C/C++/python/java
- Commands, attributes, properties
- Multi-thread
- Events support

*All new servers in tango*
What is SPEC for the beamline?

- Command Line Interface
- Main sequencer
- Handle diffractometers geometries
- Device controller:
  - *Integrated in SPEC*
  - *Taco interface*:
    - Motors / Counters
    - MCA / CCD
- Generic Interface to:
  - Serial Line
  - GPIB
  - Socket
  - Taco / Tango
SPEC macros

• Macro motors:
  • Physical: ICEPAP (socket), piezo (GPIB), …
  • Calculational: slit offset/gap, 3 legs table, …

• Macro counters:
  • Physical: eurotherm, lakeshore, …
  • Calculational: ratio, attenuators transmission, …

• Other Macros:
  • Other type of devices: beam shutters, filter box, …
  • New sequences: exafs scans, gap scans, …

→ Very flexible: many devices/sequences written
→ Limited data types, no debugger, no multi-threads
Continuous scans

• From Sequential
  - MOVE
  - EXPOSURE
  - READOUT
  - Time

• To Paralell
  - MOVE
  - EXPOSURE
  - READOUT
  - Time

• Practical Issues
  - Distributed System
  - Multiple detectors
  - Short exposure time

  • Synchronization
  • Data Buffering
Continuous scans: synchronization

- By software:
  - Synchro. with time: no wiring, good on single host
- By hardware:
  - Needs wiring, good for distributed hosts
  - Synchro. with time: P201, OPIOM boards
  - Need more: motor position, mixed time/position, ...

**MUSST board**

- Very flexible event generator
- 6 x input signals:
  - Digital counter
  - Analog
  - Positioning (motor steps and encoders)
- 16 x digital I/O
- Host Interface: GPIB
Continuous scans: data buffering

- **Software implementation**: **HOOK**
  - Kernel driver + TACO device server
  - Hardware readout + buffering
  - For In-house developed hardware
    - PCI and VME boards
  - Software event generator

- **Hardware implementation**: **MUSST**
  - Encoders, motor steps
  - Counters, ADC
  - Canberra MCA (ICB)

- **Data handling**:
  - SPEC polls data buffers
  - Counters / motors saved by SPEC
Continuous scans: detectors

- Canberra MCA (ICB)
  - Data buffering on MUSST
- XIA XMAP
  - PXI board – 4 channels
  - PXI/PCI bus coupler
  - External sync. Signal
  - 4MB memory / board
  - Data buffering in TACO

Spectras saved by device servers
Integrated ROIs transferred to SPEC (online plotting)

_CONFIGURATION ISSUES_
→ 10 ms / spectra
→ 1 ms / spectra (one board)

→ Configuration issues
→ No generic counter interface
2D detectors

- TACO CCD interface in SPEC
  - Many CCDs supported:
    - Princeton, Sensicam, PCO, Andor, Photonic Science, …
  - Standard macro set
  - Beam parameters, Multi-frame buffer, Parallel saving, …
    - Per device development

LIMA: Library for Image Acquisition

- Reuse of common code ⇒ generic procedures + interfaces
- Support recent fast detectors
2D detectors: LIMA

- Hardware layer
- Control layer
  - Software “features” fallback if hardware has limited capabilities:
    - RoI, Binning, Frame Accumulation
  - Basic processing and data reduction:
    - Beam parameters, RoI statistics, parallel saving, dark subtraction…
  - Specific data reduction algorithms through “plug-ins” (C++)
- Low level: C++ (multi-threaded)
- High level: C++ / Python (SIP)

- Generic TANGO interface + detector configuration
- Currently integrated: Pilatus, Frelon, Maxipix
2D detectors: ESPIA card

- Designed to interface the FReLoN 2k
- Collaboration $\Rightarrow$ ESRF + SECAD, S.A.
- 2 Gbps fiber optic link (> 100 m)
- PCI 64 bits / 66 MHz
- $\sim 180\text{ MB/s}$ maximum data rate
- FOCLA: 2xCameraLink connectors

**FReLoN HD (PSB-2)**

2048 x 1024 @ 32 fps $\Rightarrow \sim 125\text{ MB/s}$
2D detectors: Medipix2 / Maxipix

- Pixel detector $\Rightarrow$ photon counting
- 256 x 256 – 13 bit
- 0.3 ms readout time
- Max: 1400 fps $\Rightarrow$ 180 MB/s

- Maxipix: Medipix2 array 5x1,2x2
- Image reconstruction in LIMA
  - 1000 fps $\Rightarrow$ 650 MB/s

- ESPIA next generation:
  - PCI-Express 8x lanes
  - 4 fiber optic links @ 250 MB/s $\Rightarrow$ 1 GB/s
Online Display

- Standalone tool for visualisation (python/Qt)
- Work online: use **SPEC** shared memory
- Work offline: specfiles, edf files, hdf files
Beamline GUI: BlissFramework

- Written in python/Qt – MVC architecture
- GUI application is made of “cemented” bricks
- Communication to SPEC: server mode
  - Socket interface
  - SpecClient python module
- First GUI: MxCube (MaxLab, Soleil, Bessy)
Beamline GUI: example
Beamline GUI: example
Evolution : on-going

- Common 2D detectors framework : LIMA
  - More detectors to come
  - New interface in spec
- More beamline GUI:
  - BlissFramework4 ready
  - First application : BioSaxsCube
- TANGO to replace TACO whenever possible
- Hardware upgrade : replace VME
Evolution

- Integrated beamline configuration tool
- Continuous scans
  - Easier integration on beamline
  - Easier integration of detectors

- New data format:
  - Specfiles + EDF Files ⇒ HDF5
- Experiment database: I SpyB ??

- keep SPEC ??
Evolution: alternatives to SPEC

- Evaluation of 3 control systems:
  - GDA (diamond)
    - Most advanced solution
  - SARDANA (alba)
    - Based on already used tools (python, qt, tango)
    - No beamline yet
  - In-house solution
Conclusion

• Keep improving existing system

• Maintain support of running beamlines

• Prepare new upgrade beamlines (start in 2011)

• Investigate new solutions
Thank you!
Continuous scans

- configuration
- start event
- HW trigger
- data buffering
- data polling
- datafiles

DISPLAY

SPEC

storage

XMAP TACO

HOOK PCI / VME boards

Motor Encoder

XMAP PXI crate
2D detectors: Camera Link

- **FOCLA module**
  - Connects to ESPIA
  - 2 X Camera Link connectors
  - Multiple pixel packing formats
  - Test image generator @ ~180 MB/s

- **Dalsa Pantera 1M60**
  - Frame transfer technology
  - 1024 x 1024 @ 60 fps ⇒ **120 MB/s**

- **Sarnoff CAM512**
  - 2 x 8 ADCs – 12 bit
  - 512 x 512 @ 300 fps ⇒ **150 MB/s**
  - 512 x 128 @ 500 fps ⇒ **125 MB/s**