Architecture and highlights of control system for GM/CA CAT macromolecular crystallography beamlines

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What is GM/CA CAT?

The GM/CA Collaborative Access Team (CAT) at the Advanced Photon Source is established by the National Institutes of Health's National Institute of General Medical Sciences (GM) and National Cancer Institute (CA) to build and operate a national user facility for crystallographic structure determination of biological macromolecules.

One bending magnet and two undulator beamlines at a canted undulator are being constructed.

More info at:  
http://www.gmca.aps.anl.gov
Canted undulator beamlines

**Typical Single Undulator**
- Synchrotron Radiation
- Insertion Device
- Electron Beam

**Dual “Canted” Undulators**
- 1 mrad
- Deflecting Magnets

**Extra X-ray optics elements compared to conventional beamlines!**
Challenges to GM/CA control system

• automated beamline alignment (important for fast throughput and because of extra optical elements on canted undulator beamlines! fast scans)

• accommodation of small crystals down to 10μm in size (extra requirements to beam focusing bimorph mirrors, and beamline stability PID loops),

• automated sample centering (small crystals, high throughput fast scans, computer controlled on-axis visualization & image recognition)

• interface to robotics sample changers, and ergonomic GUI (fast throughput!)

• data acquisition with provisions for remote control and FedEx crystallography (firewalls, Access Grid)

• big detectors (8TB ultra fast storage!)
GM/CA approaches to beamline control system

**Basic approach**: use a combination of well established mainstream solutions that guarantee long lifetime and support from the community.

*Do not re-invent the wheel!*

- EPICS as the bottom layer (huge community; used throughout APS)
- Blu-Ice by SSRL as a user interface for data acquisition preferred by the community
- 8TB Storage Area Network (SAN) per beamline for data (ultra-fast fiber-based industrial solution)
Choice of Blu-Ice as user interface – user friendliness
Control system architecture – initial design

Staff beamline automation tasks
- automated beamline setup and alignment.
- BPM-based intensity and position feedback systems.

Blu-Ice interfaces for beamline users
- APS controls:
  - undulator
  - ring status
  - EPS, etc.

DCSS
(Distributed Control System Server)

EPICS IOC

CCD

Robot

motors

electronics: scalers, digital I/O DAC, ADC
Bimorph mirrors control
APS controls:
- undulator
- ring status
- EPS, etc.

EPICS-DHS

DHS

Scripting Engine

VIDEO CAMERA

Automated sample centering

bridge between the two systems that has to be developed
Interaction between Blu-Ice and EPICS

Implementated in the fall of 2003
Control system architecture – evolution of design

**Original**

- Database Configuration
  - DCSS, LDDB
  - DHS, LDDB
  - MySQL DB

- EPICS DHS (socket API)
  - Motion Thread
  - CCD Thread
  - Robot Thread

- DCSS
- Scripting Engine

**Now**

- Database Configuration
  - EPICS DHS (C/C++ API)
  - MySQL DB
  - Motion
  - CCD
  - Robot

- EPICS
  - EPICS Scripting Engine

- Hardware drivers

**GUI**

- GUI-1
- GUI-2
- GUI-3

- NOBUGS’2004

- Exchange between GUI(s) via EPICS!
- Converted BluIce into client like MEDM!
Details of Blu-Ice integration

- Database Configuration
  - MySQL DB
- EPICS DHS
  - (C/C++ API)
  - State notation data acquisition (frame)
- PMAC Motion Controllers
- CCD
- Scalers
- Shutters
- fluoresceint detector
- Support soft DB
Blu-Ice: using EPICS as DCSS

Example:
users registration stored in EPICS DB
Highlights of EPICS-level controls

- 32-axis PMAC motion controllers (GMCA)
- MAR CCD interface (CARS, Mark Rivers)
- Bimorph mirrors interface (ELETTRA, Roberto Pugliese group)
- BluIce Support controller & State Notation data acquisition (GMCA, in development)
- NOBUGS'2004
EPICS support for 32-axis Turbo PMAC2 Ultralite motion controller

Turbo-PMAC:
- any type of motors
- provisions for fast scans
- Remote (at motors)

2-3 cards control one beamline

See separate talk by Oleg Makarov!
Fast scans

- possible with PMAC (motors synchronization by controller)
- May be as fast as 1 second when using multichannel scalers
- Collaborate with BIOCAT – *see talk by Sergey Kozyrenko*
GM/CA CAT Network configuration

- 1000/100-base copper switch
- Fluorescent detector controller
- Bimorph mirrors controller
- 3-HP XW8000 Workstations
- HP eva3000 2TB fiber 80MB/s
- HP msa1000 6TB SCSI 30MB/s
- Cisco 3750 12x 1Gb ports fiber/copper
- 3-HP XW8000 Workstations
- HP DL380 SAN access server
- HP ML350 data backup server
- HP DL380 SAN access server
- 100/100-base copper switch
- Network/Fiber, 1Gb
- Network/Copper, 1Gb/100Mb
- ACCEL
- GM/CA
- VME
- VME
- MAR control computer
- HP DL380 SAN access server
- HP 2Gb SAN Switch 2/16
- HP 2Gb SAN
- Bimorph mirrors controller
- Robot
- NOBUGS’2004

Pioneering Science and Technology

National Institutes of Health

Pandora

ACCEL

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**Plans**

- finishing port between Blulce and EPICS (implementing Collect and Scan tabs).
- installing and interfacing sample mounting robot (ALS robot & EPICS controls by NSLS?).
- implementing sample centering (several algorithms under consideration; also work with commercial company on).
- setting up remote access (Citrix or Access Grid – use SER-CAT experience.
- setting up web-accessible beamtime scheduling database (port someone’s system – CARS?).

NOBUGS’2004