CANADIAN LIGHT SOURCE - PHASE II BEAMLINE CONTROL SYSTEM STATUS UPDATE *

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Abstract

The Canadian Light Source is in the final commissioning stages of its six Phase II beamlines. These beamlines make use of both EPICS based control as well as experiment data acquisition using a common underlying framework. This paper outlines the approach adopted in deploying control system on this phase of beamlines. The beamline control system make extensive use of QT toolkit and EDM for operation screens and the CERN Root package for data visualization.

BEAMLINE CONTROLS

The CLS has adopted a common approach to beamline and accelerator control across the facility based on EPICS. The control systems on all CLS beamlines make use of the same basic architecture and share the following traits:

- Machine protection is implemented using Telemecanique Momentum PLC equipment. The CLS has been effectively using the Momentums in this application since 2000. The EPICS interface to the PLC utilizes Modbus over TCP/IP.
- Personal Safety Systems (Lockup and Oxygen Level Monitoring) is implemented using the Siemens S7/400 PLC platform in a IEC 61508 compatible configuration [1].
- Serial device monitoring is implemented using the Moxa Linux [2] based computers running EPICS.
- Motion control is implemented using VME crates with optical links [3] and the ProDex MaxV or OMS58 motion control card. The majority of motion control applications are implemented using stepper motors, while servo motors are used in special applications.
- Several different VME boards are used for data acquisition, however the SIS 3820 scalar is the most common in use.
- Operator screens are developed using the EPICS EDM window manager form Oak Ridge. Operator workstations are Scientific Linux based.
- A suite of standard EPICS drivers have been developed and shared across various beamline and accelerator applications.
- Common server applications such as EPICS gateways, data archiving, analysis software are hosted on VMware virtual machines.

When and where possible, while taking into account the unique requirements of each beamline, end-station and data acquisition software components are shared.

Though mostly Linux based, a few vendor furnished MS-Windows machines have been integrated into the EPICS based control system.

SCANNING AND DATA ACQUISITION LIBRARIES

A common library of data acquisition and EPICS channel access routines were originally developed for the phase I beamlines. This library has QT C++ [4] and ROOT [5] interface classes, allowing easy integration of EPICS controls into custom graphical user interfaces. This builds on existing features such as nested and parallel scans, highly configurable action sequences (e.g. delays, monitored waits), and highly configurable readout lists.

As part of phase II recent changes include dynamic loading and registration of output functions, allowing custom data output format and media without rebuilding the calling application. Further work is underway to use the library with Java. The library is also used as the scanning engine for ScienceStudio [6].

BIOMEDICAL IMAGING AND THERAPY BEAMLINE (BMIT)

BMIT consists of both a bend magnet and insertion device beamline intended initially for animal imaging and human imaging capable. Due to it's intended application is poses special licensing and development considerations, especially in terms of human factors engineering[7]. The control system is still in an earlier stage of development.

CANADIAN MACROMOLECULAR CRYSTALLOGRAPHY FACILITY (CMCF 2)

The CMCF 2 beamline augments the capabilities of the existing CMCF 1 beamline. This beamline is currently in an advanced commissioning stage. The beamline controls make extensive use of a locally developed EPICS pseudo motor that is shared with other beamlines.

CMCF 2 makes use of vendor furnished software for the Micro diffractometer end-station[8]. Originally supplied with a CORBA to EPICS interface, working with the vendor CLS developed a replacement based on TCP sockets and EPICS asyn [9].

The Stanford Auto-mounting Robot[10] was selected for the beamline. In collaboration with Stanford and AS, the pre-existing BlueIce/Dcss software was integrated

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into the EPICS based control system. A Python based graphical user interface called MXDC was also developed [11].

The robot will allow CMCF II to become increasingly more automated, and allows for remote users. Work is under way to permit users to submit their setup data, approve strategies, and review results over a web interface. The interface between the web application and the beamline executive is through a relational database and FTP. This simplifies providing remote users with a consistent interface for configuring experiments while providing flexibility in changing the beamline software.

RESONANT ELASTIC AND INELASTIC X-RAY SCATTERING (REIXS)

The REIXS beamline has a dedicated Elliptically Polarised Undulator (EPU) and the capability of using light from a second identical EPU from an adjacent beamline [12]. The insertion device and beamline control software are all EPICS based. In the two EPU mode of operation each EPU can be set to different polarizations and a chopper causes light from the EPU to alternate on the target at the end station.

The EPUs uses the legacy OMS VME58 cards and standard CLS software. Heidenhain linear encoders provide a direct read out of the EPU gap at the upstream and downstream ends of the EPU and four girder positions. All polarizations such as circular left, circular right, linear horizontal and linear polarizations from -90 to +90 degrees can be set. EPICS State Notation Language (SNL) is used for closed loop control and a procedure that coordinates calibration of upstream and downstream encoders and the four girder encoders.

The chopper is driven by a servo motor using a MAXv card. The signal from the in vacuum chopper encoder is split. One signal is used by the motor software for positioning the chopper when stationary in single EPU mode. In the two EPU mode the other signal is input into a custom board which will alternately enable two channels on an SIS3820 multichannel scalar used for data acquisition.

The REIXS monochromator control for the mirror and grating uses in-vacuum encoders. Each encoder is equipped with four read-heads and acquired through a Heidenhain IK320 VME board; the heads are averaged and accessed at approximately 50 Hz. By using a running average a position resolution of 0.00001 degrees is attained, providing an energy resolution of 0.02 eV at 100 eV and 0.5 eV at 2000 eV.

Control of the EPUs and monochromator are synchronized during a scan by means of an energy application implemented in SNL. By setting an EPICS PV for energy the end station software can set gap and girder positions for both EPUs, and also mirror and grating angles. Feed-forward is implemented using multi-column lookup up tables for phase and energy are used for gap and girder positions. Offsets can be set for fine tuning gap and monochromator settings.

SOFT X-RAY MICROCHARACTERIZATION BEAMLINE (SXRMB)

SXRMB is located on a bend magnet port. SXRMB has been commissioned up to the first end-station area. Active development on a custom QT GUI for users is in the final stages of testing and debugging, until complete, commissioning software provides sufficient capability for beamline commissioning and early science. The installation of hardware and software for the second end-station area has been scheduled to be completed before the end of 2009.

SXRMB has two solid state detectors (SDD), a Sahara single-element silicon drift detector from Princeton Gamma Tech (PGT) and a 4-element Vortex SDD detector. Both are controlled through EPICS, the PGT with a driver written at the CLS and the Vortex using the synApps dxp (Xmap) application. Current from slit blades, ionization chambers and channel plate detectors are measured with Keithley 6485 picoammeters, some of which will be replaced with a combination of Stanford SR570 current-to-voltage amplifier, voltage-to-frequency converters and an SIS3820 32-channel VME scalar. The amplifiers and scaler are also under EPICS control. CLS-developed EPICS controls have been installed for an OceanOptics QE65000 spectrometer for XEOL studies, but the detector has not yet been commissioned at the beamline. The EPICS QE65000 driver has been used on other beamlines. All of these EPICS-controlled devices are read out by the CLS standard data acquisition and channel access library embedded in the graphical user interface.

SYNCHROTRON LABORATORY FOR MICRO AND NANO DEVICES (SYLMAND)

SyLMAND is an X-ray lithography beamline on a bend magnet port, and process support laboratories in a clean room environment.

The core components of the control system for SyLMAND are currently in place. The beamline is capable of operation when the storage ring is operating at low current. An intensity chopper, designed and assembled at CLS, will be installed in late 2009. The intensity chopper will allow the beam exposure time to be varied from 0-50% or 100% with the chopper moved out of the beam. The main components in the beamline are the chopper, beam slits to reduce the beam size, a double mirror system, flying wire beam position detectors, and the scanner endstation.

The machine protection system for the double mirror stepper motor control system was augmented with a Momentum PLC based potentiometer feedback and motor disconnect system. This independent machine protection system will not allow the mirrors to be moved beyond certain velocity, a pitch of 45mrad, and to avoid a mirror clash. In addition, the potentiometer reading is brought into the EPICS software for the mirror system. This software also monitors the high resolution encoders on each of the mirror motors. The EPICS software monitors and also interlocks based on feedback versus set point values for position, and velocity This is augmented with hardware limit switches for pitch, clash and end of travel.

The end-station scanner, built by Jenoptik, has a pre-existing vendor furnished control system. The scanner software was integrated with the EPICS based control system. The Scanner Control System also provides a hardware interface to the beamline PLC for valve and shutter control, and vacuum status.

VERY SENSITIVE ELEMENTAL AND STRUCTURAL PROBE EMPLOYING RADIATION FROM A SYNCHROTRON (VESPERS)

VEPSERS is a hard X-ray microprobe beamline designed for X-ray micro-diffraction (XRD), X-ray micro-fluorescence (XRF) spectroscopy analysis, and X-ray absorption spectroscopy (XAS). The beamline uses a bending magnet source, double crystal/multilayer monochromator, and compound optics to deliver a multi-bandwidth or polychromatic beam. Currently, the beamline is in its late commissioning phase and full user operation will begin in 2010.

The machine protection system for VESPERS is similar to other phase II beamlines. However, on the M2 mirror motor control system, some augmentations have been made to ensure that the internal hardware limit switches do not allow a mirror clash by stopping all motions if a limit is actuated. Additional EPICS software has been developed to implement software limits on motions where hardware limit switches are difficult or impractical to install. The soft limit software was mainly used for the end-station detector and sample stage motors that have the possibility of clashing.

The beamline employs several flying wire beam position monitors, and view screens to diagnose the position of the beam. Also, current measurements from slit blades, and a split ion chamber provide continuous feedback for beam position. A closed loop system to stabilize the beam is developed for energy scanning.

The current end-station setup consists of a diffraction CCD, and a single element detector to obtain fluorescence spectra. There is also a microscope to view the sample. The scanning and data acquisition software for the beamline is currently under development, however one dimensional absorption scan and two dimensional Laue diffraction and spectra mapping scan software is currently in use.

Additional scanning software to provide wire scanning across the sample will also be developed. The scanning software has been developed using the QT graphical user interface and the CLS data acquisition and EPICS QT libraries. The CERN ROOT data analysis and graphics toolkit has also been used for the 2D scanning displays.

VESPERS is also the initial target beamline for the ScienceStudio web-based user interface.

CONCLUSION

The use of a common approach to beamline controls has permitted the CLS to effectively leverage software across all of its beamlines. This has permitted us to allocate additional resources to the more specialised data acquisition requirements of each beamline.

The CLS has, were appropriate, leveraged pre-existing software both from the EPICS collaboration and other projects. In the case of non-EPICS applications custom interfaces have had to be developed or obtained from collaborators to permit an effective integration.

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