NSLS II CONTROL SYSTEM

G. Carcassi, L.R.Dalesio, D.Dohan, N.Malitsky, G.B.Shen, Y.Tian, BNL, Upton, NY, U.S.A.

Abstract

The NSLS II is a new third generation light source. The project is pushing control system technology in three areas: fast orbit feedback, use of RDB technology, and model based control architecture. This paper describes these developments in terms of the overall control system architecture.

INTRODUCTION

The National Synchrotron Light Source II is a new 3rd generation light source being built at the Brookhaven National Laboratory in Upton, New York. This new facility is planned to be operational in the 2013 time frame. In the early stage of the project, one main focus of the project is to complete any long term developments that can improve performance, productivity, and functionality. Three areas that are identified as high value improvements are: Physics Applications Environments, Relational Database Tools for Configuration and Documentation, and Hardware Components for Fast Orbit Feedback.

PHYSICS APPLICATIONS ENVIRONMENT (PAE)

Physics applications provide tools for commissioning and operations. There are a number of tool sets that are available in the community including: SAD[1], SDDS [2] (Self Describing Data Sets), XAL (eXtensible Accelerator Lanuage)[3], and MMLT (Matlab Middle Layer Toolkit)[4]. Each of these tool sets exchange data between through some variety of data structures, files, or methods. None of components of these tools have been interoperable with another tool set. Our effort in this area is to create a client-server architecture that provides narrow and well defined interfaces to provide different implementations of similar functions such as orbit correction..

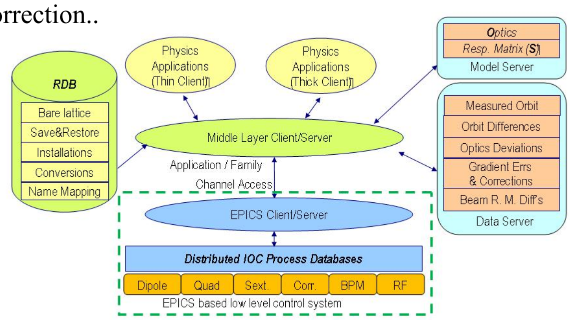

Figure 1: High level applications design goal.

(PAE) CLIENT/SERVER APPROACH

The approach to developing a client/server architecture for physics applications was to begin to evaluate protocols on which the required network functionality could be accomplished and to examine some existing models to determine what data was required for each a model server. The accelerator models most used at NSLS II are Tracey III[5] and Elegant[6].

Communication protocols that were evaluated included: DDS-Corba[7], DDS-RTI[8], and ICE[9]. Several man-years were expended to study the DDS API, DDS available protocols, and ICE. DDS, as an open standard, appears to be a promising application programming interface (API) for physics applications. In each of these protocols, the performance was too slow or access to the source code was too restrictive. A hybrid solution was considered. The EPICS[10] Channel Access Protocol[11] and TINE[12] were both considered as they have demonstrated adequate performance The hybrid that is being prototyped consists of the DDS API over with the Channel Access protocol. It is currently operational and shows the flexibility needed in the API and the performance desired on the wire. The data is currently serialized and de-serialized in the DDS layer and transported through EPICS V3 arrays. In the next year, a prototype will be developed using EPICS V4 communicating PV Data structures directly.

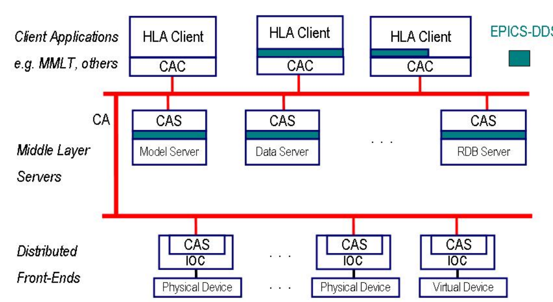

Figure 2: DDS API with Channel Access Protocol.

We currently have all of the model based control and display applications of MMLT running against either Tracy III or Elegant as the model engine. The models are wrapped in a library layer to produce the same data structures. We also have a separate prototype using a DDS API and CAV3 protocol[12] to get beam parameters from the UAL[13] model. These are very significant steps towards providing a full client/server implementation that supports clean interfaces for compute servers, machine parameter servers, and instrumentation servers to a variety of thin clients and fast prototyping environments.

RDB TOOLS FOR CONFIGURATION AND DOCUMENTATION

The IRMIS RDB tools were developed at Argonne National Laboratory for documenting a system that was deployed. The tools counted on crawlers to discover configuration information about the system from the various files. At NSLS II, IRMIS II[14] was used as a base to develop tools that allowed us to capture all of the system parameters needed to document the facility. We have extended these tools so that we can document the equipment by defining all component types, components, and wiring. For all of these, IRMIS can capture the housing hierarchy, the power hierarchy, and the control hierarchy. This data is then available for problem resolution during the life of the facility. There is also support for lattice information. Scripts were developed to take Tracy or Elegant lattice files into the IRMIS tables and to produce either Tracy or Elegant input decks. There is also support for installation documentation and inventory tracking for inventory, installation, and maintenance support. An advanced directory service exists in IRMIS to relate Process Variables to functions and location on the beam lines. This allows the development of generic applications that can request parameters by function and location. Examples of this would be vacuum readings for the LINAC or beam position monitors for the storage ring.

The electronic group has started to capture their data for rack, power supply and magnet information. The tools allow incremental data capture. Several iterations of on have been accomplished by entering the first two cells of the storage ring and then using tools to replicate the data for the other twenty eight repeating cells. The screen capture shows that the housing hierarchy is completed and the lattice information is captured. It is ready to extend for port definition, wiring, power, and control.

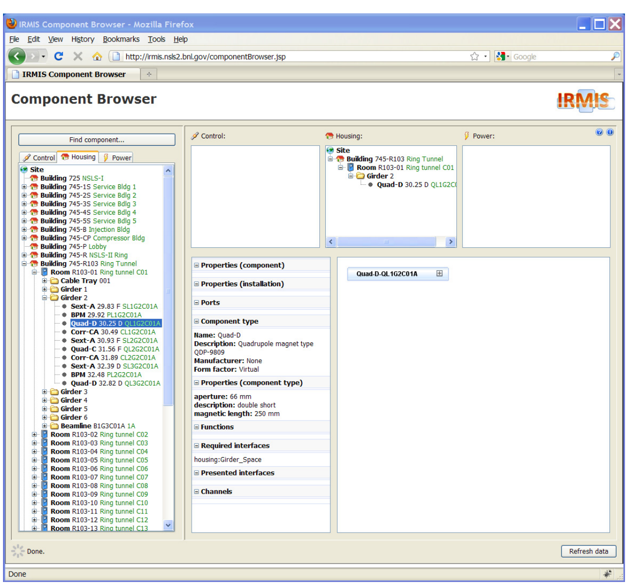

Figure 3: IRMIS component editor.

As the preliminary designs are completed over the upcoming months, the project engineers will use these tools to document the remaining components and fill in the control hierarchies for the component types. As the final device lists are made over the next year, all of the instances of the devices will be documented. As the power and wiring plants become clear, those final details will be added to the IRMIS database. Servers will be developed to provide information from IRMIS for use for by tool for commission and operation. These modifications are being released as IRMIS III [16][17].

HARDWARECOMPONENTS FOR FAST ORBIT FEEDBACK

To talk about the fast orbit feedback system, it is necessary to talk about the Beam Position Monitors, Communication, and Power Supply Controllers. To achive 10 KHz feedback, the entire time budet must be considered.

The overall budget target is 50 microsecs to acquire data from the BPMs, into a fast deterministic cell controller. The cell controllers has 20 microsecs to collect all BPM data for the storage ring to every other cell controller. The last 30 microsecs is used to compute the new setpoints, set the power supplies and have the fast correctors settle.

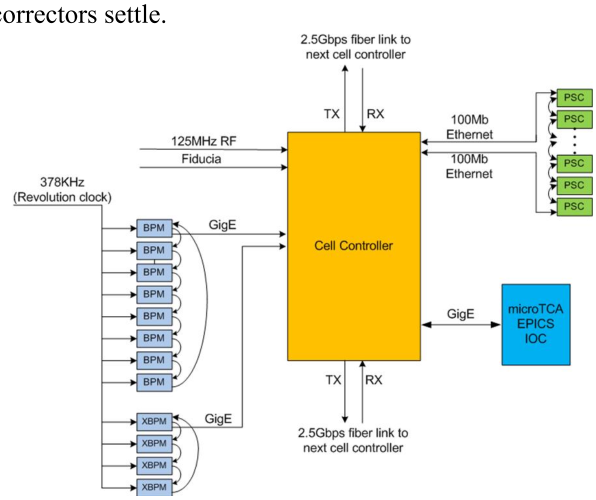

Figure 4: Cell controller.

The Libera Brilliance[18] module is the baseline design for the NSLS II beam position monitors. The measured delay for data through this module was 57 microseconds. Grouping will be used in each of the 30 cells. Each cell will collect up to twelve local BPMs, through the fast link, to one of the Libera modules. All of the BPM data for the cell is then communicated to the Cell Controller.

There are 30 cell controllers. They have interfaces to collect the local BPM data, distribute the BPM data to each of the other cell controllers, and to set the fast and slow correctors in the cell. The Synchronous Device Interface[19] communcation between Cell Controllers are expected to transport all BPM data to each of the thirty cell controllers in under 15 microseconds. Each cell controller will compute the changes for the three fast correctors and 9 slow correctors in the local cell. There is 28 microseconds left to compute this portion of the matrix, communcate the new setpoints, and change the fast correctors. Improvements in the BPM communication are being investigated.

The power supplies use the same redundant communication to send the new setpoints to each of the power supply controllers.

In order to expedite the delivery of each subsystem, an Ethernet port used to communicate with each BPM and Power Supply controller. This will be used for all functionality aside from fast orbit feedback. Each device will provide full access to all data, expose all confugration parameters, and return all diagnostic infromation. In this architecture, all BPMs and power supplies should operate easily at 20 Hz. This allows NSLS II to operate through commissioning without the use of the cell controller. The cell controller only needs to be installed and operational for the 10 KHz feedback fucntionality.

CONCLUSION

The NSLS II has taken on serious development in three different areas. Each of these areas are being developed in an open source, collaborative environment.

In the case of IRMIS, we are building on what was already started at ANL. The tables and tools being developed are designed to work with any machine in the case of most of the functionality. The lattice tools are intended to work with any accelerator.

In the case of the cell controller, we are attempting to develop an open-source hardware platform that provides low latency, robust data communication that could be used for any application that requires higher bandwidth than is achievable using other technologies. As the communication occurs in an FPGA, this platform provides a benefit over other shared memory solutions that require transfer of the data into a processor for computing the new setpoints.

For high level applications, we are creating interfaces and network communication support that allows the integration of components developed at many laboratories to provide commissioning and operations tools for particle accelerators.

These are ambitious goals. Fortunately, there is an excellent team in place and a great community available for support.

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