STATUS AND PROGRESS OF FRIB HIGH LEVEL CONTROLS*

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Abstract

The Facility for Rare Isotope Beams (FRIB) is a new heavy ion accelerator facility to provide intense beams of rare isotopes currently under construction at Michigan State University. Its driver linac accelerates all stable ions up to uranium, and targets to provide a CW beam with the energy of 200 MeV/u and the beam power of 400 kW. We are actively preparing for the beam commissioning of FRIB fron end. The high level control for incoming commissioning is under active development and deployment. The latest status progress will be presented in this paper.

INTRODUCTION

FRIB [1] is a new project under cooperative agreement between US Department of Energy and Michigan State University (MSU). It is under construction on the campus of MSU and will be a new national user facility for nuclear science. Its driver accelerator is designed to accelerate all stable ions to energies > 200 MeV/u with beam power on the target up to 400 kW [2].

The layout of FRIB is as shown in Fig. 1, which consists of two ECR (Electron Cyclotron Resonance) ion sources, a low energy beam transport with a pre-buncher and a chopper, a RFQ (Radio Frequency Quadrupole) linac, LS1 (Linac segment 1) to accelerate the beam up to > 15 MeV/u, LS2 and LS3 to accelerates the beam > 200 MeV/u, two folding segments to confine the footprint and facilitate beam collimation, and a beam delivery system to transport to the target. The beam is stripped to higher charge states after LS1 section.

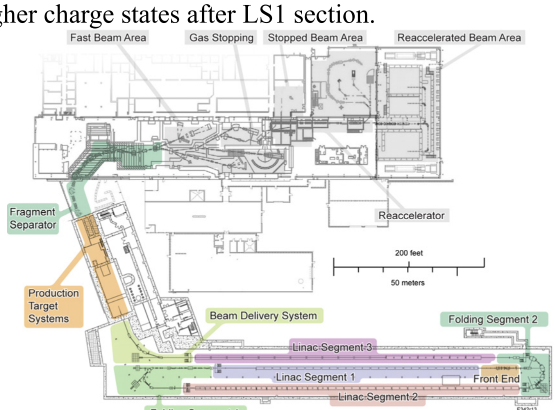

Figure 1: Layout of the FRIB driver accelerator, target and fragment separator.

ARCHITECTURE

A service-oriented architecture (SOA) has been chosen for FRIB high level controls as shown in Fig 2.

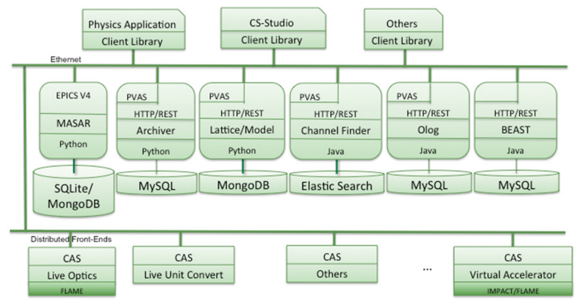

Figure 2: FRIB High Level Controls Architecture.

As shown in Fig. 2, the FRIB high level controls consists of

- Upper level, which includes physics application, software framework for user interface like CS-Studio, and so on;
- Middle layer service, which includes Archive Appliance for data archiving, Olog for operation logbook, MASAR for machine snapshot, BEAST for alarm handler, and so on;
- Low level software EPICS IOC to support the machine operation and commissioning.

More specifically, the development activities covers

- Database based web applications [3], which includes eTraveler, Cable database, Central Configuration Database (CCDB), and so on;
- Control room applications, which includes CS-Studio (Control System Studio), and middle layer services, client CS-Studio applications;
- Physics application, which includes online model, applications for commissioning and operation [4][5], and Python infrastructure.

DATABASE APPLICATIONS

There are three major database-based web applications to support FRIB construction and commissioning, which are eTraveler, Cable, and CCDB respectively.

eTraveler

A traveler is a document or a document collection to capture the history of certification or processes associated with a device.

At FRIB, an eTraveler (Electronic Traveler), as illustrated in Fig. 3, has been implemented as a database web application to create, manage the document online to track predefined processes associated with physical entities for FRIB and capture data accompanying to each step

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of the process. Most travelers have some similarity with checklists but additional information like comments and pictures can be captured as well. Some major functions implemented in eTraveler system include:

- User defines work process and data-collection template;
- Access is controlled by owner via sharing with individual users and groups;
- History of data changes is tracked;
- API (Application Programming Interface) for integration into other applications;
- Users can define work packages composed of travelers and other packages with values and priorities (to be delivered)

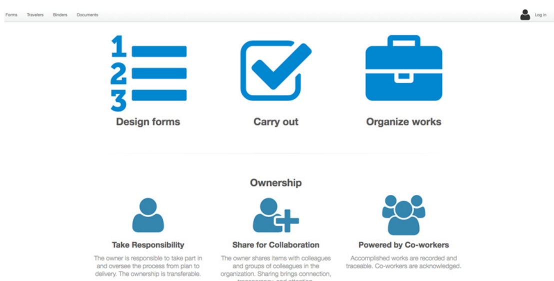

Figure 3: FRIB eTraveler Application.

We currently have 3833 travelers, and 1297 of them are active with 1971 of them completed.

Cable Database

Cable application is developed to manage FRIB cable specifications and meta-information like cable types, cable pulling status, and so on. The current implementation supports:

- Manage cable specifications and meta information like cable types;
- Access control by ownership, roles, and responsibility;
- Support full cable lifecycle;
- Request, approval, revision, pulling, testing, and obsoleting;
- Support construction, commission, and future operation;
- Provide cable information to other applications.

Figure 4 shows an example of our current production deployment.

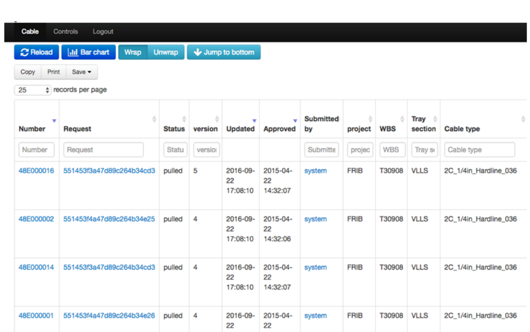

Figure 4: FRIB Cable Application.

To support the construction activity better, it supports reporting function. User can plot the cable according the WBS (Work Breakdown Structure), status, cable section, cable type, engineer, conduit, and so on. Figure 5 shows an example to plot the cable counts against different signal types.

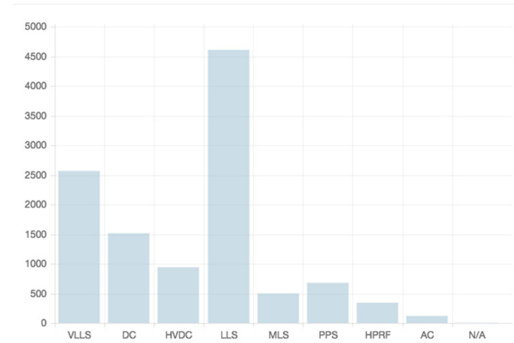

Figure 5: FRIB Statistics With Different Signal Types.

Currently at FRIB, we have 11276 cables loaded into Cable database, and 1638 of them have been pulled.

Central Configuration Database

The CCDB is a database web application to assist to document the approved configuration and approvals for the complete set of beamline and safety slots required to operate FRIB within the Operational Safety Envelope and Accelerator Safety Envelope.

It is one primary configuration management and configuration control tool supporting Device Readiness Reviews and Accelerator Readiness Reviews, and therefore machine operations, maintenance. A major function of current implementation is to capture component Readiness Checklists, which can be associated with devices, slots, or groups of slots. Device Readiness Checklists capture that devices meet the requirements for installation. Slot and slot-group Readiness Checklists capture that slots with installed devices meet the requirements to operate those device as a subsystem. The device defined in CCDB is a physical entity, which can be independently installed or uninstalled. The slot is a placeholder where a device to be installed into.

The CCDB has been deployed to assist our project progress, and the device and slot installation progress has been capturing as shown in Fig. 6 and Fig. 7.

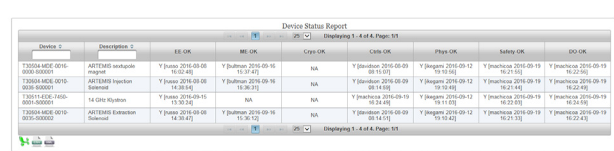

Figure 6: FRIB Device Status captured in CCDB.

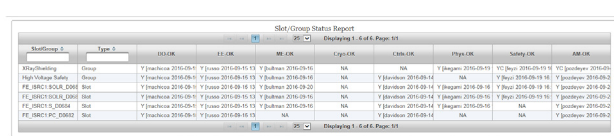

Figure 7: FRIB Slot Status captured in CCDB.

CONTROL ROOM APPLICATION

The control room applications consist of two major parts, which are control room client applications and services respectively.

As the CS-Studio is our control room application framework for client, each client application is released as one component of CS-Studio. It includes

- Data browser for historian data viewer;
- Alarm client;
- Logbook client;
- Scan client;
- Save set restore client;
- Operator interface screen;
- Electron Cyclotron Resonance (ECR) scan application;
- Tuner application;
- Channel finder viewer for EPICS Directory Service.

As a minimum set of initial deployment for middle layer services, we currently deployed

- Channel finder as EPICS Directory Service;
- Archive Appliance;
- BEAST as Alarm Server;
- Olog as Logbook Service;
- Scan Server.

The services are deployed to support on-going FRIB activities, and examples are shown in Fig. 8 and Fig. 9. Figure 8 shows a view in CS-Studio for Channel finder service, which serves as EPICS directory service.

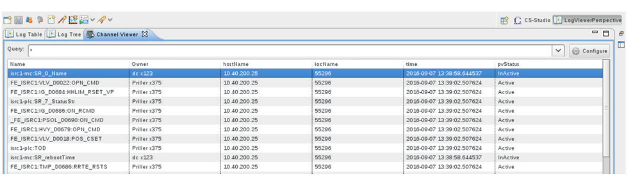

Figure 8: FRIB Channel Finder Service.

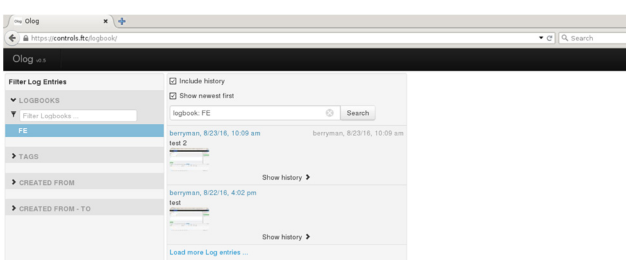

Figure 9: FRIB Olog Service.

Together with the IOC deployment for the front end ion source, the engineering CS-Studio screens have been deployed successfully, and Fig. 10 is one example for the engineering screen.

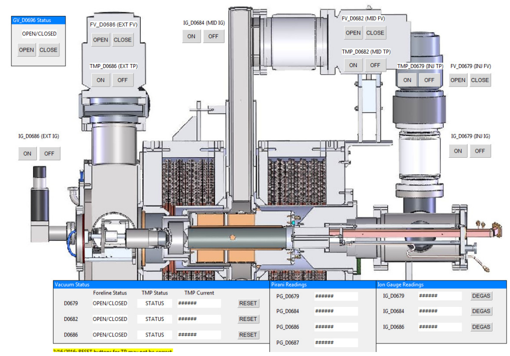

Figure 10: Engineering OPI Screen for FRIB Ion Source.

PHYSICS APPLICATION

An online model, called FLAME (Fast Linear Accelerator Model Engine), after a major refactoring in C++, has been successfully developed to meet the requirements of FRIB project [6]. It supports all major FRIB components except the RFQ, which includes solenoid, dipole, quadrupole, sextupole, RF cavity with axisymmetric and non-axisymmetric field distribution, stripper, electrostatic element (dipole and quadrupole), and also supports simulation for multi-charge state beam.

Programmatically, as Python has been chosen to be the scripting environment for FRIB physics application, FLAME provides a Python interface and the flexibility for the system integration.

CONCLUSION

A distributed service-oriented architecture has been adopted for FRIB's high-level controls. The database applications have been extensively used to support project construction, and we have successfully deployed our control room applications for the incoming beam commissioning. The FLAME online model has been successfully delivered for the physics application development.

ACKNOWLEDGMENT

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