EVALUATING THE LHC SOFTWARE ARCHITECTURE FOR DATA SUPPLY AND SETTING MANAGEMENT WITHIN THE FAIR CONTROL SYSTEM

R. Mueller, J. Fitzek, D. Ondreka, GSI, Darmstadt, Germany

Abstract

The future Facility for Antiproton and Ion Research (FAIR) puts challenges on the existing machines and controls infrastructure at GSI and shows its limitations. A control system renovation is planned to control the much larger accelerator complex in a consistent way.

At CERN the LHC Software Architecture (LSA) is a working solution for settings management and data supply, which is designed in a very generic way. LSA was developed at CERN starting in 2001 as a core part of the controls software and is used for nearly the whole CERN accelerator complex.

Because of its clear separation between data model, business logic and applications, where all accelerators are kept in one database schema, it seems to be suitable and easily adaptable to GSI/FAIR.

To analyze LSA in more detail, design how to adapt and extend it to GSI and FAIR needs and how to integrate it into the existing controls software at GSI, a prototype was set up. The existing synchrotron SIS18 was modeled in LSA. Several tests are planned to use LSA for setting generation for different machine modes, e.g. fast extraction, KO extraction.

The current state of evaluating LSA is presented here.

FAIR

The international FAIR facility will be built at GSI in Darmstadt. It includes nine new accelerator installations: a p-linac, two synchrotrons, four storage rings, the Super-Fragmentseparator and FLAIR. The facility will be built in several stages, the final facility is shown in Fig. 1. The existing linac and synchrotron UNILAC and SIS18 will act as injectors. A renovation of the SIS18 is planned to be able to deliver higher beam intensities for FAIR. For a detailed description of the FAIR facility refer to [7] and [6].

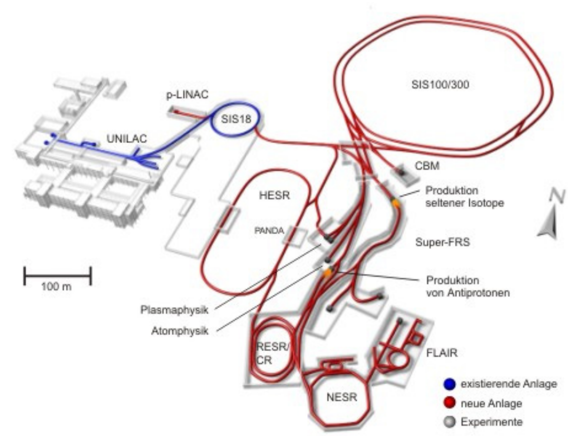

Figure 1: FAIR overview.

FAIR Control System

Already today the existing GSI facility is operated in a very flexible way, using pulse-to-pulse switching between different particle types while serving several different experiments. FAIR will significantly increase this complexity, with additional accelerators and many more parallel research programs [4]. The goal is to support all aspects of the expected functionality necessary to operate the GSI/FAIR machines on a common technical basis for all accelerators. The future control system is at the moment in the design phase, keeping well working and proven principles while adopting new methodologies where beneficial.

Keeping in mind the challenge of putting a new control system in place while the existing facility is running, it is however vital, that the new system will be commissioned with parts of the existing machine. It is planned to use the new control system software starting with the existing SIS18. Since the UNILAC injector with its highly specialized software is well established, it will continue to be controlled with the existing software, thus the present GSI controls infrastructure has to be well integrated into the new control system [5].

In the course of FAIR and its strict boundary conditions concerning personnel, time schedule and costs, by the large-scale international FAIR project, the strategy to implement new systems has to be most effective. To learn from best practices of others and to contribute to the development of larger scale generic control systems, collaborations on common topics are a promising approach.

Since CERN and FAIR have similar requirements concerning the control of the respective accelerator complex, a closer look at the CERN control system was taken. CERN had to built a new control system for LHC and the current software upgrade program for injectors, and took a generic approach, to be able to use this new solution for all parts of the machine. The working solution for settings management and data supply within the CERN control system is called LSA. The proposal is to use LSA as central component of the renovated control system at GSI.

LSA - THE LHC SOFTWARE ARCHITECTURE

LSA was developed at CERN starting in 2001 and is now the core controls software component for settings management and data supply. A detailed overview was presented at ICALEPCS '07 by CERN [1]. The LSA system was designed in a very generic way and provides a clear separation between data model, business logic and applications. The system is built in a modular way, institute specific implementation can be implemented and easily plugged in. After more than 100MY of development, LSA is now being widely used at CERN - for SPS, LEIR, AD, LHC and the transfer lines; at the moment it is deployed for PS and Booster. LSA is the abbreviation for LHC Software Architecture, but since it is now used all over CERN, only the term LSA is used.

Functional Overview

The LSA system covers all of the most important aspects of accelerator controls: optics (twiss, machine layout), parameter space, settings generation and management (generation of functions based on optics, functions and scalar values for all parameters), trim /coherent modifications of settings, translation from physics to hardware parameters, operational exploitation, hardware exploitation (equipment control, measurements), and beam based measurements [2].

A central aspect is, that an accelerator within LSA is modeled by describing its parameter hierarchy - from top level physics parameters down to hardware parameters. Together with necessary optics and the appropriate propagation rules along the hierarchy, the LSA system can already calculate good initial settings. Corrections to those settings according to measured deviations can be applied to the whole hierarchy of parameters, resulting in consistent changes of many devices at the same time. As an example for a part of such a hierarchy at GSI, see Fig. 2. The LSA system consists of different functional building

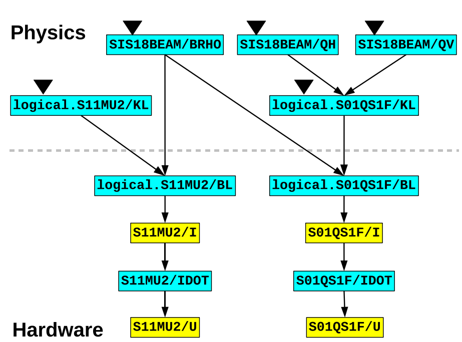

Figure 2: Example of an LSA parameter hierarchy at GSI.

blocks, which among other benefits entitles physicists to implement the machine model themselves in a structured and simple way.

Technology Stack

LSA is written in Java and is using the Spring framework, that provides a light-weight container for the Java platform, dependency injection (DI), aspect oriented programming (AOP), testing framework, remoting and transactions. An overview of the LSA software stack is shown in Fig. 3. LSA is visible to the applications trough a series of

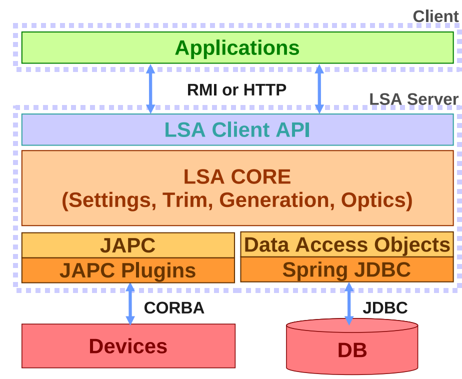

Figure 3: LSA software stack, G. Kruk, ICALEPCS 2007.

facade classes that group the functionality of LSA by topics (setting management, hardware access etc.). They represent a stable and backward compatible interface which separates applications from business logic, thus applications can concentrate on the display part.

Communication with the devices and middleware is done through a powerful abstraction layer called JAPC (Java API for Parameter Control) [3], that makes it possible to access and control devices of all accelerators using the same interface.

LSA AT GSI

Collaboration

The collaboration with CERN on LSA started in 2007 with two people from GSI being sent to CERN to work on LSA for about 3MY. It soon became clear, that LSA could be used as a basis for the renovation of the setting generation and data supply system at GSI. Therefore, in 2009 a collaboration was set up with joint development effort put into future LSA development. Presently, the collaboration is well working and ongoing.

The distributed development on LSA is organized as follows: There is one common software stack residing at the CERN repository that contains the generic LSA modules and CERN specific implementation. It is planned that GSI specific implementation (e.g. hardware access) will be managed in the GSI environment, but is at the moment still located at CERN, using the CERN build tools.

New features and changes to the common part of the LSA stack are discussed via video and telephone conference and then implemented together. Since LSA is at the moment only in a prototype state at GSI, the release cycle is decided by the CERN time schedule.

Setting up LSA at GSI

In general, the LSA system is designed in a very generic way and has nearly no hard references to the environment at CERN. For the small number of references, that cannot be resolved (e.g. CERNs online model server or role based access system), a dummy implementation had to be provided at GSI that fulfills the interface.

In principle, the LSA system runs out-of-the-box given an empty LSA database with just a few tables prefilled. First steps at GSI in 2008 included setting up such a database and an LSA test server.

After setting up the test environment, the existing GSI devices were connected to the LSA system through two new GSI specific JAPC plug-ins, which is shown in Fig. 4. Since LSA is well integrated with FESA, the CERN Front-

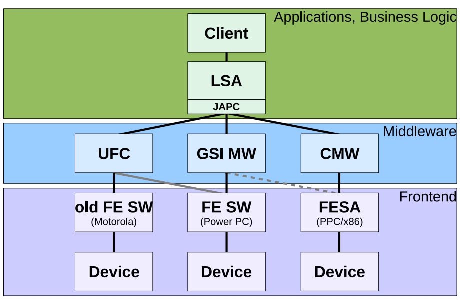

Figure 4: Three different ways of accessing GSI devices.

End Software Architecture, where evaluations started in 2006 and a collaboration was set up, FESA devices could be easily imported and then accessed from the LSA system. For all other standard GSI devices, which will continue to exist and need to be controlled through LSA, no such tight integration exists yet; information about those devices had to be imported from several sources and merged together in the LSA database. This topic is currently being investigated.

In parallel, a project team consisting of machine physicists and software developers from different groups at GSI started modeling the existing synchrotron SIS18 within LSA: defining the parameter hierarchy, implementing propagation rules, importing optics. Goal is to get experience with the system by using the accelerator at GSI and setting up defined test cycles based on real cycles from today's operating. Currently, a minimal cycle for the SIS18 can be generated with LSA, including the calculation of ramps for the main power converters and RF settings. This cycle can in principle be used to accelerate beam. Preparations are now ongoing for a real machine run of the SIS18 with LSA in spring 2010.

Extending LSA

The flexibility of accelerator operations at GSI put a new view on the LSA system. In particular while modeling the SIS18, certain restrictions were found within the LSA machine model, resulting from the rather static operation of the accelerators at CERN. Based on these observations, ideas for modifications to the LSA machine model were developed within the collaboration. For some of these topics a final solution has been agreed upon and implementation has already started.

A future topic for discussions will be the modeling of a chain of accelerators, especially modeling of inter-accelerator dependencies, which are necessary for FAIR. Also at CERN, the focus shifts towards controlling the full accelerator chain. This change in perspective is related to the fact, that now the same control system is used for many accelerators at CERN. First brainstorming on this topic has started, but will be continued in the near future.

So far, it seems that all of the requirements now coming from GSI are also of interest for CERN. The goal of both involved parties is clearly to make LSA as generic and flexible as necessary to be able to really fulfill all requirements, that arise from complex accelerator operations.

SUMMARY/OUTLOOK

The technical decision to use LSA at GSI for settings management is a promising approach, since it is mature, widely used at CERN and very generic and seems to suit the GSI requirements already quite well. Additional requests for flexibility can and were already implemented based on a very close and fruitful collaboration.

Since both partners respect each others efforts to a common goal, also the future of the collaboration is ensured and GSI looks forward to the first LSA tests with beam foreseen next spring.

Getting to know LSA in more detail, the project group at GSI will in a next step focus on the modeling of the existing storage ring in LSA. New requirements might arise, which are to be implemented by the joint LSA development team.

REFERENCES

[1] Grzegorz Kruk et al, "LHC Software Architecture (LSA) - Evolution Toward LHC Beam Commissioning", ICALEPCS'07, Knoxville, Tennessee, USA, WOPA03

[2] M. Lamont, L. Mestre et al, "LHC Era Core Control Application Software", ICALEPCS'05, Geneva, Switzerland, TH1.4-8O.

[3] V. Baggiolini et al, "JAPC - the Java API for LHC Timing Parameter Control", ICALEPCS'05, Geneva, Switzerland, TH1.5-8O.

[4] P. Schütt, U. Krause et al, "Operation modes and controls aspects of FAIR", ICALEPCS'05, Geneva, Switzerland, PO1.011-1.

[5] Ralph C. Bär et al., "Development of a New Control System for the FAIR Accelerator Complex at GSI", ICALEPCS'09, Kobe, Japan, TUP107.

[6] Ralph C. Bär et al., "The new FAIR accelerator complex at GSI: project, controls challenges and first steps", ICALEPCS'07, Knoxville, Tennessee, USA, TOAB01.

[7] Peter Spiller, "FAIR at GSI", HB'06, Tsukuba, Japan, MOBP02.