Evaluating the LHC Software Architecture for Data Supply and Setting Management within the FAIR Control System

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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

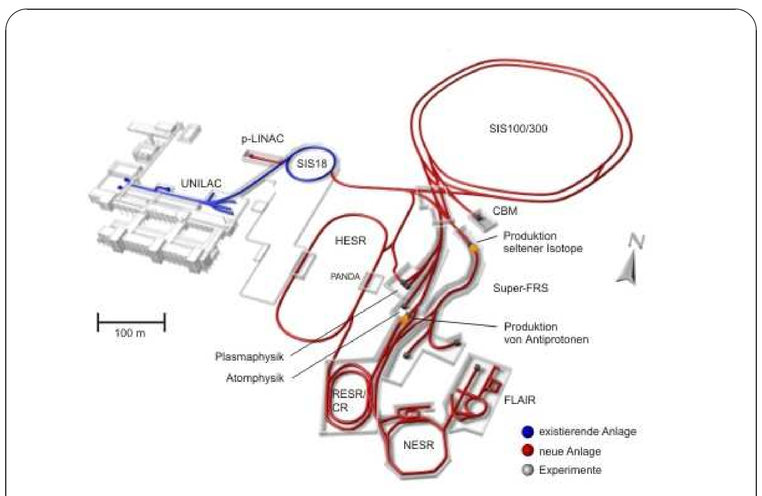
- Nine new accelerator installations
- Built in six stages, existing facility will act as injector
- Pulse-to-Pulse switching between particle types
- Increased complexity because of parallel experiments

FAIR Control System

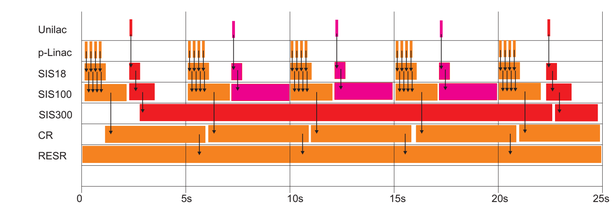
- Support all operation aspects of the GSI/FAIR machines
- Existing facility running continously
- Will be comissioned with the existing machine
- Starting behind UNILAC with SIS18
  (but UNILAC needs to be well integrated)

Strategy

- Learn from best practices
- Collaborate on common topics
- Contribute to development of larger scale control systems



FAIR overview



FAIR beam pattern example

Collaboration with CERN

- Similar requirements for injector chain
- Project associates from GSI were working on the CERN control system (3 MY of work)
- Good experience with settings management, generation and data supply (LSA)
- Proposal to use LSA for data supply at GSI/FAIR

Organization/Coordination

- Common software stack (e.g. interfaces, generic implementations) at CERN
- Seperated set of laboratory specific packages for GSI and CERN
- Changes or enhancements are elaborated via phone and video conference and implemented together
- Because of LSA's modulare design splitting implementation tasks is often possible
- Prototype state at GSI suggests to follow the CERN time schedule

LSA - THE LHC SOFTWARE ARCHITECTURE

Covers most important aspects of accelerator controls

- Optics (twiss, machine layout)
- Settings generation and management
- Translation from physics to hardware parameters
- Operational exploitation, hardware exploitation, equipment control, beam based measurements

Parameter hierarchy (tree) as a central aspect

- Physics model is kept in a seperate package of the LSA Framework, this encourages physicists to implement the machine model themselves in a structured way
- Physics parameters on the top level, hardware parameters on the lowest level
- Hierarchy and physics model describe how the change of a physics parameter influences the hardware parameters
- Corrections can be applied on every level in the hierarchy and are kept seperatly from the theory values

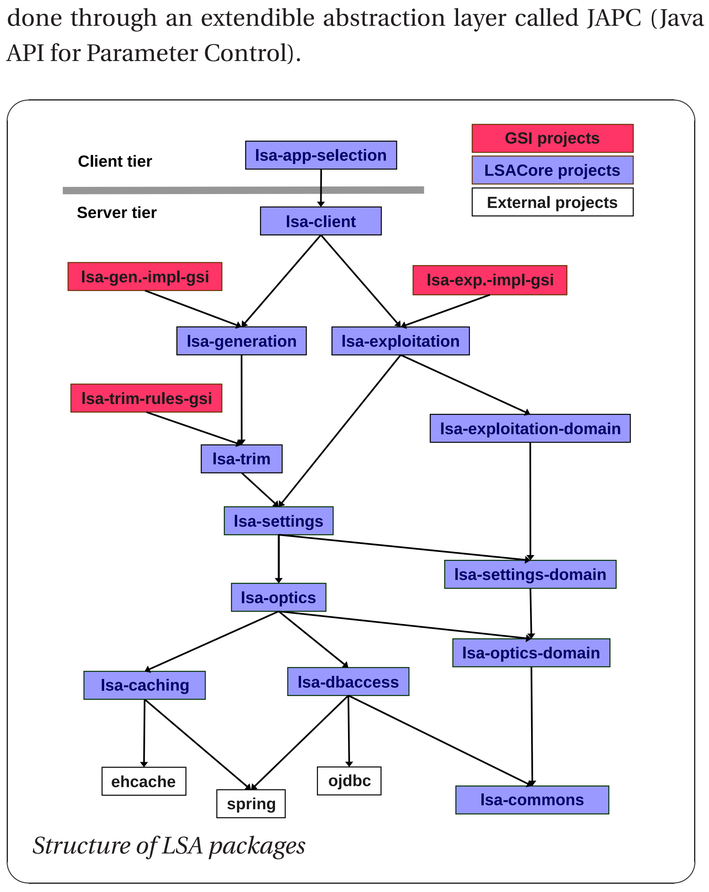
Designed in a very generic way with clear seperation of

- data model
- business logic
- applications

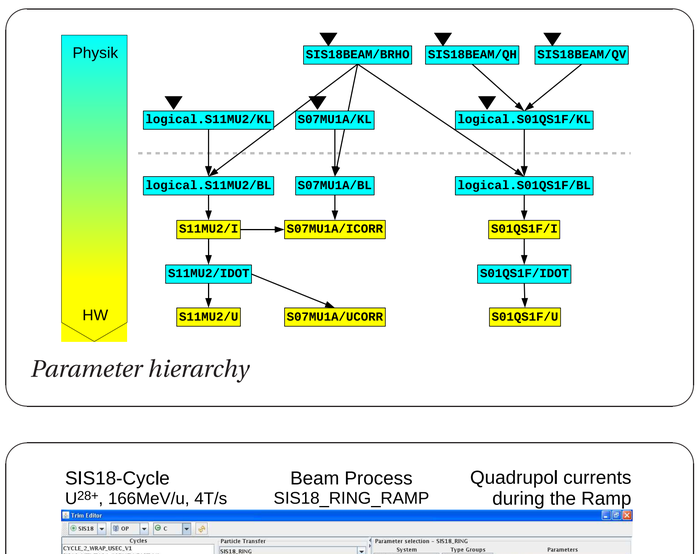
Developed using

- Seperation of data model, business logic, applications
- Light-wight container (Spring)
- Dependency injection (DI)
- Aspect oriented programming (AOP)
- Remoting
- Transactions
- Extensive JUnit tests

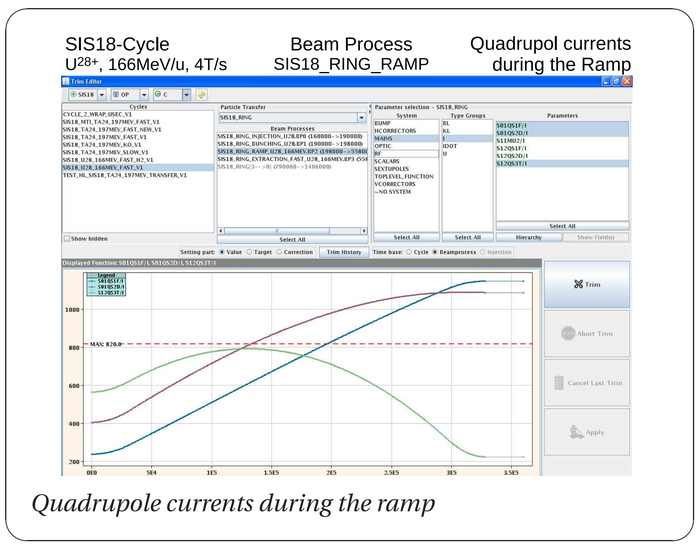
LSA's business logic is visible to applications through a set of facade classes. Communication with devices and middleware is done through an extendible abstraction layer called JAPC (Java API for Parameter Control).



Structure of LSA packages



Parameter hierarchy

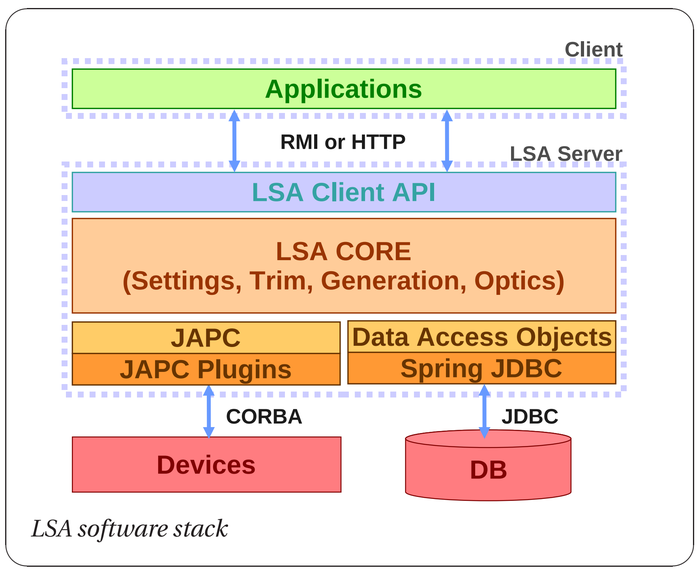


Quadrupole currents during the ramp

LSA AT GSI

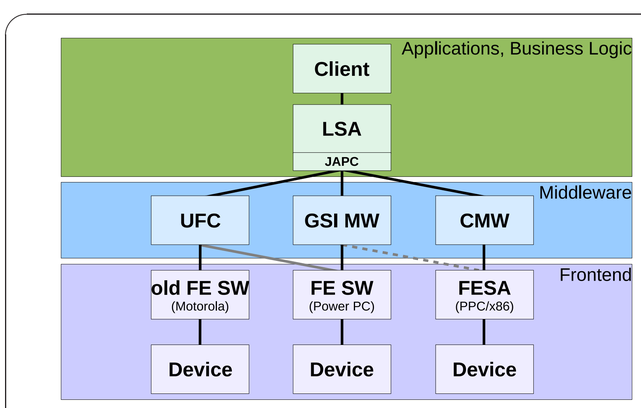
✔ Test server setup
- Intel Xeon (Quadcore @ 2.66 GHz)
- 4 GB of RAM
- 1000 MBit Ethernet
- Red Hat Enterprise Linux 5.4
- Oracle Database 10g Express Edition (10.2.0.1.0)
- Java Development Kit Version 1.6.0(_06)
- Eclipse with development tools

✔ Setting up LSA core
- Very generic, nearly no hard references to CERN environment
- GSI provided dummy implementations for the few references encountert (like role based access)
- LSA database needed only a few prefilled tables



LSA software stack

✔ Connecting the core to the hardware
- Accessing FESA test devices residing at GSI worked well after importing them from the GSI-FESA database
- JAPC plug-ins needed to be provided for access to GSI specific devices and middleware
- Import scripts were developed to import devices and properties from GSI configuration files into the LSA database
- A lot of work needs to be done to get an appopriate level of automation for data import ...
- ... ease of hardware integration depends on the complexity of the hardware and existance of structured descriptions of data sources (e.g. the HW interfaces)



Three ways of device access at GSI

☞ Parameters and Settings
- A project team for FAIR data supply was created consisting of machine physicist (5) and SW Developers (3)
- Preparation of a parameter hierarchy for the existing synchrotron SIS18, implementation of propagation rules and import of optic information
- Gained experience with the system by defining test cycles based on real cycles from todays operating
- A minimal cycle that is suited for operating SIS18 can already be generated with LSA, including ramps and RF settings

☞ Extending LSA
- Restriction due to rather static operation at CERN (e.g. fixed cycle length)
- LSA models accelerators one by one -> future topic will be modelling a chain of accelerators

SUMMARY/OUTLOOK

- Technical decision to use LSA at GSI for settings management is promising, LSA suits GSI requirements quite well
- Both collaborating partners want to improve LSA further, new requirements that may arise will be discussed by the joint LSA development teams
- After modeling the synchrotron SIS18 at GSI the project group will focus on the ESR (Experimental Storage Ring) to get to know this part of LSA in more detail
- GSI looks forward to the first LSA test with beam in the SIS18, foreseen in next spring

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