Realization of a Concept for Scheduling Parallel Beams in the Settings Management System for FAIR

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Abstract
Approaching the commissioning of CRYRING, the first accelerator to be operated using the new control system for FAIR (Facility for Antiprotons and Ion Research), the new settings management system will also be deployed in a production environment for the first time. A major development effort is ongoing to realize requirements necessary to support a coherent operation at FAIR. The basic idea is to pattern multiple similar devices controlling the whole facility with so-called parallel bases in a layered way, being able to control central parts of the new control system already at CRYRING before the first FAIR accelerators are commissioned. It facilitates an early proof of concept and testing possibilities. Concurrently, enhancements and implementations of the currently used UaS (Unified Software Architecture) framework take place. At CERN, the interface to LHCb has been redesigned to enhance maintainability and diagnostics capabilities. At GSI, support for polynomials as a native data type has been implemented, which will be used to represent accelerator settings as well as calibration curves. Besides functional improvements, quality assurance measures are being taken to increase code quality in prospect of production use.

Commissioning of CRYRING at GSI
- Installation nearly complete, very few additional components to be integrated
- Commissioning of hardware ongoing, deployment and testing of whole control system stack is about to commence
- Major milestone from a controls perspective, as CRYRING will be the first machine solely operated via the new FAIR control system

Parallel Beam Scheduling Concepts for FAIR
- Optimize the number of concurrent research programs
  - Up to five beams in parallel
  - Pulse-to-pulse switching between different particle types
- Allow for great flexibility
  - Change the parallel operation schemes on a daily basis

Recent Enhancements of the Framework
Polynomial data types
- Before polynomials were available, all functions data had to be provided in a discretized form
- Truly continuous while consuming less memory as they are represented by coefficients instead of x-y pairs
- Both calibration curves (from the magnets group) and settings (e.g. for ramped devices) are supported

Data supply subsystem
- Core motivation was to improve diagnostics capabilities of the system
- Joint effort between CERN and GSI
- Data supply results were formerly presented in a flat structure for the whole process
- New hierarchical result classes allow operators to trace errors down to individual parameters, e.g. in case a set value is rejected by a front-end controller
- Particularly beneficial when supplying large numbers of devices and for handling error states during commissioning

Quality Assurance Measures
- Facilitate focus, correctness and test coverage for mission-critical components
  - Implementation of the parallel beam scheduling concept and the data supply system overhaul was carried out using a test-driven development approach
- Minimize potential errors during commissioning of CRYRING
  - Intensive code reviews of machine model
  - Automated integration test suite using mock-up front-end device controllers

Test-Bed for the new FAIR Control System
- Validate concepts and technologies under real-world conditions
  - CRYRING is equipped with its own injector line, so it can operate independently of the existing accelerator chain
  - CRYRING does not imply the same requirements as FAIR will, but core concepts can nevertheless be tested
- Parallel beam scheduling concept will be utilized at CRYRING for the first time

Status of the FAIR Settings Management System
- Development is currently focused on CRYRING and implementing the parallel beam scheduling concepts
- Reference settings for CRYRING successfully calculated using the pattern scheduling mechanisms
- Integration tests with the other control system components are being conducted

Outlook
- Enhanced CRYRING operation
  - Synchronization between previous and new control system is able to transfer beams from ESR to CRYRING
  - Beam manipulation during the cycle for experimentation phases
- Towards full FAIR operation
  - Scheduling a beam production chain multiple times as a sub-chain to consistently model e.g. SIS18 in booster mode for SIS100
  - Multiple active patterns to serve experiments that require beam on demand