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MYRRHA CONTROL SYSTEM DEVELOPMENT*

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Abstract

MYRRHA ADS (Accelerator Driven System), the prototype of a nuclear reactor driven by a particle accelerator, is being realized through a staged approach. This paper will explore the Control System (CS) strategy for the current stage of the accelerator R&D, where the goal is injector for the energies up to 5.9 MeV. Accelerator components are being delivered within international semi-industrial partnerships. Currently the RFQ, MYRRHA's first RF structure, is being introduced. It will be followed by the first Medium Energy Beam Transport (MEBT1) and several normal-conducting CH cavities.

As the portfolio and number of devices and systems grows there is increased push towards standardization of integration procedures, interfaces to system-wide services, configuration management. Several partners provide components with varying level of vertical integration. The responsibility of the Control System integrator is therefore shifting towards provision of integration guidelines, configuration and deployment of central services and management tools, training to the contributing developers, help with specifications and requirements, quality insurance and acceptance criteria.

TECHNICAL CONSIDERATIONS FOR CONTROL SYSTEM

A team responsible for control system integration will be established, which will provide a common standardized framework for all who contribute to the control system. The standardized framework will consist of hardware platform recommendations, software toolkits and development processes. The standardized framework, built on EPICS control System, will drastically minimize integration effort and need for re-work in the integration stage of the R&D phase [1], since the components would not only use common communication protocols, but would also follow similar development processes, and would therefore be easier to maintain by the integration team. The control system integration team will also oversee the design and acceptance of deliverables from partner institutes with the objective to streamline the partner institute's development activities by offering advice and support, and by ensuring minimal compliance to the development process.

The accelerator control system interacts with several stakeholders and systems of the MYRRHA ADS. The interfaces with other parts of the facility are presented in Figure 1. The main control system subsystems are: (1) the control system core, (2) the control box, (3) configuration, (4) the development environment and (5) user interfaces.

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Figure 1: the main control system subsystems and interfaces with stakeholders.

Control System Core

Provides accelerator-level services. It is further broken down in subsystems. The purpose of personnel protection system (PPS) is to ensure safety of the personnel. The machine protection system (MPS) guards the equipment from damage. The timing system (TS) precisely synchronizes time critical actions in the accelerator. Alarm system notifies operators of deviations from normal state where operator action is required. Archive system monitors and stores process values of interest in a central database. The control system framework provides a common communication protocol which enables efficient communication and data exchange between accelerator components.

Control Boxes

Interface to front-end controllers that connect to sensors and actuators. They perform real-time data acquisition from different sensors (e.g. pickups, cameras, gauges, encoders, etc.), analysis and control of the actuators (motors, currents, pumps, power supplies). It also exposes device interface via the control system communication layer. This hides the complexity of low-level communication with devices from its users, and enables users to manipulate device process variables, data and states in a unified way.

Configuration

Configuration is centralized storage of the control system configuration. It provides tools, mechanisms and procedures to manage, access and deploy the configuration of the control system components. Configuration adheres to

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control system conventions e.g. naming convention, user interface schema etc.

Development Environment

The development environment provides services and tools that facilitate software consistency and compatibility. It provides development procedures, code sharing, versioning, testing, storage, deployment and other functions. It also provides a controlled way to develop and deploy upgrades of the control system.

Human Machine Interface

The human machine interface provides accelerator control system users with a graphical and command-line interface. Users use HMI to configure, control and monitor accelerator systems and components. The structure of HMIs represents different levels of machine detail. Overview screens show high level machine status and are the entry point for control. They incorporate control of machine operation modes and provide an aggregated view of main systems and their statuses. One level below them, operator screens focus on operation workflows. Further down, engineering screens provide verbose insight into component's settings and statuses. The level of detail of engineering screens is useful for diagnostic purposes but is impractical for accelerator control, therefore its most important parameters are used to assemble the screens that operators will use in day-to day operations. Hierarchy of GUIs will enable the user to traverse from overview GUI via Operator GUI to any engineering GUI. Textual HMI will also be available in a form of text editors and console windows. Graphical displays will follow common colour schema and GUI conventions.

ORGANIZATIONAL CONSIDERATION OF CONTROL SYSTEM

Control System team or integrator will have to consult and understand the requirements of contributors, their use cases to come up with relevant control system design. Design phase will drive the selection of interfaces, along with selection of HW and SW platforms. A catalogue of preferred HW and SW should be devised. A special attention to MYRRHA availability should be taken during the CS design phase.

Another objective of CS team is to assess possible synergies with similar projects namely ESS. The shared knowledge, development, combined with necessary experience will have positive effect on resource needs and design and development timeline. From the perspective of coordination, an increase on management effort should be expected.

Early standardization should be endorsed by the integration team. Benefits of standardization can be expected in terms of integration, maintenance, support effort and conversely needed resources (team size). The goal should be to define CS building blocks through use of catalogue, conventions, development and configuration tools that all contributors use.

Vertical integrations of featured devices should be provided by use of the catalogue as much as feasible. This will reduce the need for later re-work and integration efforts originating from diverse and divergent equipment, interface and software platform selections. It will also allow to spend much less effort on integration and dedicate more focus on reliability studies.

Migration of prototypes developed in R&D phase will require certain commitment of resources. Complete set of devices will realistically not be ported to unified platform(s); therefore, a flexible development environment will be needed to encompass different SW versions, HW platforms, OS versions etc. Environment that originated from PSI (and was later adopted by ESS) seems a good option to achieve this [2]. Adaptation for MYRRHA needs should be considered.

Integration of control System should start in parallel to equipment development. The contributors will develop equipment and it is recommended they provide standard interface for integration. If they plan to provide certain level of CS integration with the device the development guidelines should be followed. Provision of development guidelines is a responsibility of CS team.

As soon as the interfaces between accelerator equipment and CS are defined, integration into control system should start. Only this will ensure the Software support will be ready on time when equipment is finalized.

It is also beneficial that regular intermediate integration tests are performed where equipment and software is tested.

It is important the CS Team is involved in decisions about HW/SW options to complement decision process with the CS perspective. Think design for integration. To achieve standardization the integrator should be involved immediately after Physical properties and Analog front-end (e.g. conditioning + sensors for the Beam instrumentation and/or LLRF is defined). Discussions about digitization platform (dynamic range, sampling rate, throughput, accuracy, precision, reaction time, data bus, interfaces, triggers) should put the integrator in the loop. Ideally SCK•CEN would endorse common hi-end CS HW platform everyone would use.

Certain contributors might choose to deviate from recommendations. This should be well understood in terms of additional integration, support, maintenance effort and justified with SCK•CEN.

Overall MYRRHA will require the following range of Control System integration activities through its lifecycle:

- Writing requirements, design, acceptance documents, review of requirements, design for contributions, approval.
- Provide and maintain standardized CS ECO-SYSTEM (HW, SW catalogue, workflows) to mitigate risk of diverse & divergent systems as much as feasible.
- Train contributors to use it.
- Support device integration for contributions.
- Do own integration and support integration of contributions into CS.

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- Support availability, and beam recovery studies.
- Perform commissioning, operation and maintenance of the facility.

REFERENCES

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[2] ESS EPICS Environment for EPICS bases, https://github.com/icshwi/e3-base