VIRTUAL ACCELERATOR CONTROL SYSTEM FOR DEVELOPMENT STAGE OF APPLICATION-ORIENTED PROJECTS

M. Sugimoto, JAERI, Tokai, Ibaraki, Japan

Abstract

The design of the control system needs to be started from the beginning stage of the development for the application-oriented accelerator projects, to make the commissioning period short and to achieve the highest availability. Such a project usually consists of several co-operating sub-facilities and the network-based computer control is employed. One of the best choices as the remote terminal is the Web-based PC because of the accessibility and the cost-effectiveness. The concept of the fundamental tasks is described to implement the control system into the PC environment. It provides the control experiments for the operators through the operation of the virtual machines during the development phase. The experiments give the good opportunity to receive the feedback from the machine users and to support the planning of the repair and maintenance procedure. The virtual components will be replaced to the actual devices in the construction phase step by step. An example of the experimental control system is presented for the International Fusion Materials Irradiation Facility[1] (IFMIF).

1 GENERAL CONSIDERATIONS

The design approach starts with the requirement analysis of the facility and such requirements should be described in the conceptual design documentation. As a boundary, the generic control system of the facility is considered to employ a multi-layered and distributed environment as shown in Figure 1. Based on the terminology of Ref. [1] of the IFMIF conceptual design, the top layer is the Central Control System and Common Instrumentation (CCSCI) which provides the overall operational and functional control capability to the facility. The common instrumentation covers the interfaces of the sub-facilities and the facility management, e.g. access control, radiation monitoring. The second layer consists of the Instrumentation and Control Sub-Systems (ICSS) for the sub-facilities fairly independent to each other. The accelerator system control is one part of the whole facility control and the relation to the other parts is also taken into account at the same time. The further sub-layers can be added to each ICSS for managing them as the hierarchy of the structure. The major distinction between CCSCI and ICSS is the capability of communicating to the outside of the facility. In the common layer the Interlock Logic System (ILS) and the Sequence Synchronizer System (SSS) characterize the accelerator-based facility. In the figure the two other important constructs, people (operator and user) and materials (machine, **specific** knowledge and environment), are not indicated. The employed procedure is presented in Table 1 to apply the analysis and design of the IFMIF system.

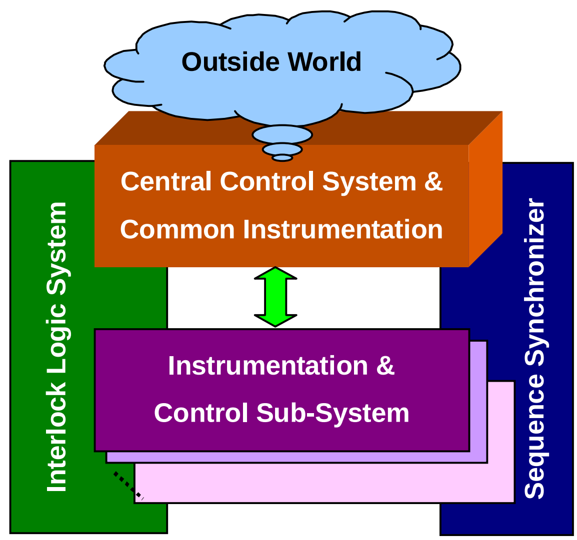

Figure1: Generic model of accelerator control system.

Table 1: Procedure of System Analysis & Design

Step	**Item**	**Resource**
(1)	Requirements	Design Specifications
(2)	Elements Types	Work Breakdown Structure
(3)	Operations Actions	Design Descriptions
(4)	Scenarios Contexts	Design Documents of Facility Operations
(5)	Domains Classes	Similar Systems
(6)	Attributes Behaviors	"

[1] http://efrosf.frascati.enea.it/ifmif/

2 IFMIF PROJECT

2.1 Requirements Overview

The IFMIF is an accelerator-based D-Li neutron source to simulate the neutron field environment of D-T fusion reactor for developing the radiation-resistant and low-activation materials. The conceptual design study has been carried out through 1995-1998 under the IEA collaboration (Japan, US, EU, Russia) [1,2]. The IFMIF design concept is based on the user's requirements of the irradiation neutron field (Table 2) and the total current of 250-mA of deuteron beam is expected to obtain the enough irradiation volume and neutron intensity.

Table 2: Design requirements of IFMIF

Items	Requirements
Neutron flux / Test volume relation	more than 0.4 L for a high flux region with 20 dpa/year
Neutron spectrum	first wall spectrum peaked near14 MeV as near as possible
Neutron flux gradient	< 10%/cm
Machine availability	70 %
Time structure	Quasi continuous operation

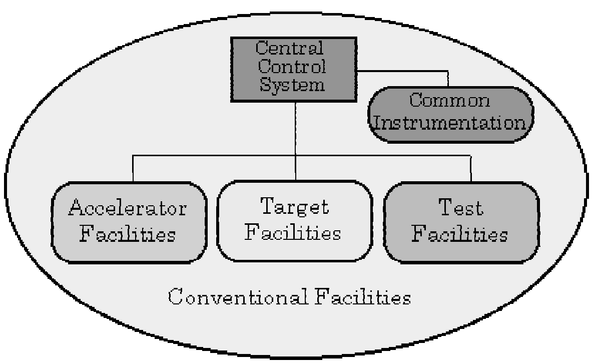

Figure 2: Schematic structure of IFMIF subsystems.

The IFMIF consists of the following sub-facilities, as shown in Figure 2.

- Accelerator facility provides two independent 125-mA, 40-MeV cw deuteron beams to the target.
- Target facility accepts 10-MW beam to the liquid lithium flow with 15 m/s.
- Test facility embodies the tiny samples packed into 500 cm^3 volume for fast neutron irradiation tests.
- Users experimental facility handles the in-situ and the post-irradiation experiments.
- Facility services supply the common utilities to all sub-facilities.

The requirements for the control system are as follows.

- Single and integrated central control system.
- Functionally provides all command, communication, diagnostics, data acquisition, and safety tasks for all project phases.
- Availability exceeds 99.5 %.
- Interfaces with subsystem controllers, operators, accelerator, target, test cell, and facility including support utilities.
  - Physical interfaces are mechanical, electrical connection and shielding.
  - Signal interfaces are LAN, serial/parallel bus, and hard-wired logic lines.
- Operational requirements are:
  - Automatically, and/or interactively, start-up and control operation.
  - Provide timing, set point control, state sequencing, and designated functions.
  - Acquire, process and display system status, beam performance, and operating parameters against limits.
  - Monitor and display alarms and parameter trend.
  - Provide fault detection and recovery.
  - Provide fast-protect and run-permit functions.
  - Provide data acquisition, formatting, storage, archiving, analysis, display presentation.

The conceptual design report indicates an example configuration to perform the crude cost estimation. We are sure that this estimate about hardware is not much different from the real cases at the construction, however, the software cost is unpredictable if all above requirements are completely satisfied.

2.2 System Analysis

Firstly, the requirements are reorganized in the form of Use Case diagrams. The human factors are very important in the plant-level operation, so that the model needs to include them. Many analyses for every complex system have been already carried out and some representative models are established in the past. The three types of (1) real-word, (2) technology and (3) axiomatic domains[2] are effective in our case. The most components and devices are involved in the real-world domain, and technology domain covers the software-related constructs. The typical and abstracted actions are considered as the axiomatic domain. It is worth to define these actions clearly using the domain diagrams for the further analyses and improvements. In Figure 3, an example of the collaboration diagram for changing the set point data of a device.

As for the IFMIF operations, three different modes are identified.

[2] http://www.espritinc.com/

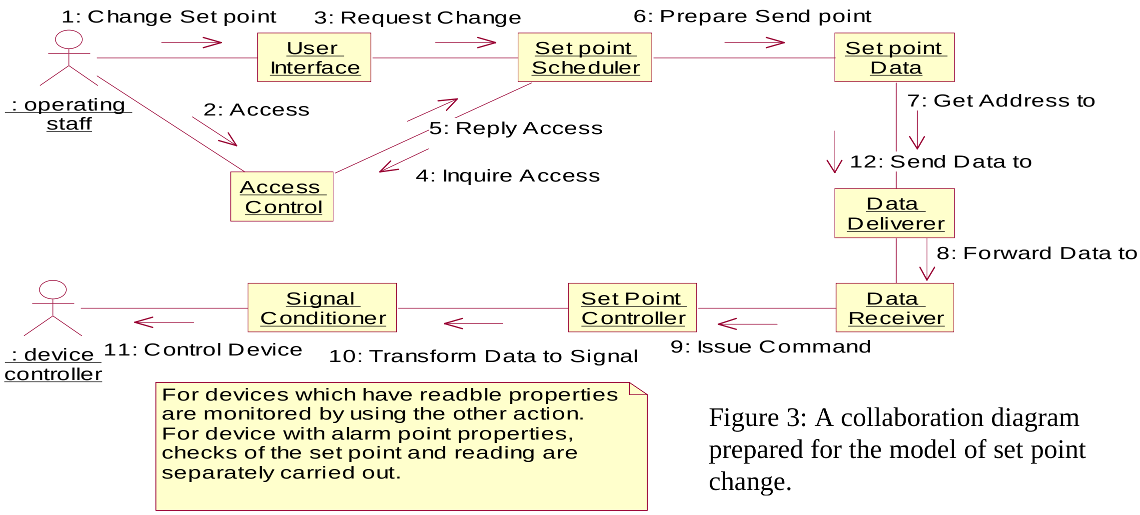

Figure 3: A collaboration diagram prepared for the model of set point change.

(1) In the start-up mode all subsystems are synchronized to achieve the steady operation as early as possible where the interface problems are most stringent.
(2) In the steady operation mode the usual feed-back loops stabilize the system and some predictive approach is necessary for achieving the maximum availability.
(3) In the failure recovery and maintenance mode, the immediate judgement of the continuation of operation is critical. For this purpose, a long term operation experiences and the proper analysis is necessary. This leads us to start the experimental control system task from the beginning of the development stage as described below.

3 EXPERIMENTAL CONTROL

The application-oriented accelerator system should be designed with the highest efficiency as the top priority like an industrial plant. From the technology side, the Reliability/Availability/Maintainability & Inspectability (RAMI) is the critical issue. It is essential to accumulate the RAMI database for each component before the steady operation of such plant. The experimental control system on the virtual facility is helpful to acquire the experience about the operations and to refine the system models. So it is necessary to be closely coupled with an experimental operation database and an analysis program to extract the RAMI information.

4 PC IMPLEMENTATION

The idea described above is generic and can be implemented in any platform, however, it is convenient to start the development with a PC platform because of the richness of the available development tools. We employ an object-oriented CASE tool to analyze the requirements and design the necessary components. The present implementation is a trial to evaluate the web browser based control terminal with a pseudo-GUI. An example is shown in Figure 4, which uses DHTML and ASP technique.

5 CONCLUSIONS

The control system of the plant-like accelerator-based project must be considered by taking into account of the interactions among all subsystems, human and environment. It is helpful to develop the models for the later precise design and implementation. The other ways for implementing the web browser based control are planned.

REFERENCES

[1] IFMIF CDA Team, (Ed.) M. Martone, “IFMIF International Fusion Materials Irradiation Facility Conceptual Design Activity Final Report”, ENEA RT/ERG/FUS/96/11, December 1996
[2] IFMIF Team, (Ed.) A. Moeslang, " IFMIF International Fusion Materials Irradiation Facility Conceptual Design Evaluation Report”, FZKA 6199, December 1998.

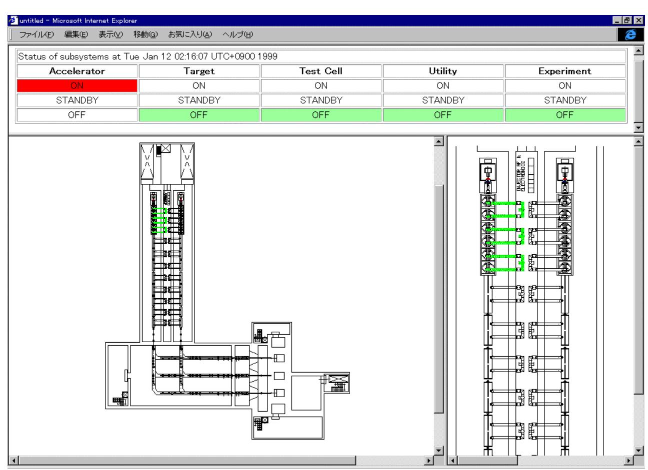

Figure 4: Web browser based diagramtic display.