The Control System of ROSY I

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ROSY I is a planned synchrotron radiation light source with a number of straight sections for wigglers and undulators for photon energies in the range from 1 keV to 20 keV [1]. This paper describes the design principles of the fully distributed architecture of the ROSY control system, pointing out the extensive use of de-facto standards for both hardware and software such as UNIX, X11/Motif, VMEbus etc. Particular attention is given to the implementation of the man-machine-interface, the design of the distributed online database, the homogeneous communication architecture and the integration of data processing and feedback in the realtime environment of the process layer.

1 Introduction

Most modern accelerator control systems build on the same principles: a distributed architecture and standardization towards open systems. The control system of the ROSY I synchrotron light source is no exception. It is specially designed for high bandwidth on all layers and, due to envisaged future upgrades and expansions, seamless extension in capacity and capability.

The architecture of the ROSY control system is inspired by the newly designed control system for the Storage and Stretcher Ring ELSA [2], which is under development at the physics institute of the University of Bonn.

2 Guidelines

The following guidelines were set for the design of the ROSY control system:

- The basis is a distributed system with several loosely coupled logical layers providing failsafe operation and allowing scalability. The intelligence and computing power for the handling of local tasks and computations is transfered to lower layers whenever possible.
- Transparent behaviour of the complete control system and in particular of the communications between the logical layers of the control system from the viewpoint of both the user and the application developer.
- The widest possible use of standards for all hardware and software components allow for a minimal implementation time and simplify service and support.
- A common development platform for all software components on the workstations and use of development tools for software engineering and documentation.

3 Architecture

The architecture is made up of four logical layers (see figure):

The **presentation layer** consists of several UNIX RISC-workstations running the X11 and OSF/Motif windowing system. A man machine interface – based on the system developed at ELETTRA[3] – is providing the interactive control of all parameters. Other user oriented applications like orbit correction are also activated on the presentation layer.

The **control layer** is formed by several powerful UNIX RISC-computers. Each of them is in charge of the autonomous control of a subsystem of the accelerator complex. The architecture and software of the control system allows for the seamless addition of further computers for new subsystems. The control computers manage a distributed, memory resident online database, which

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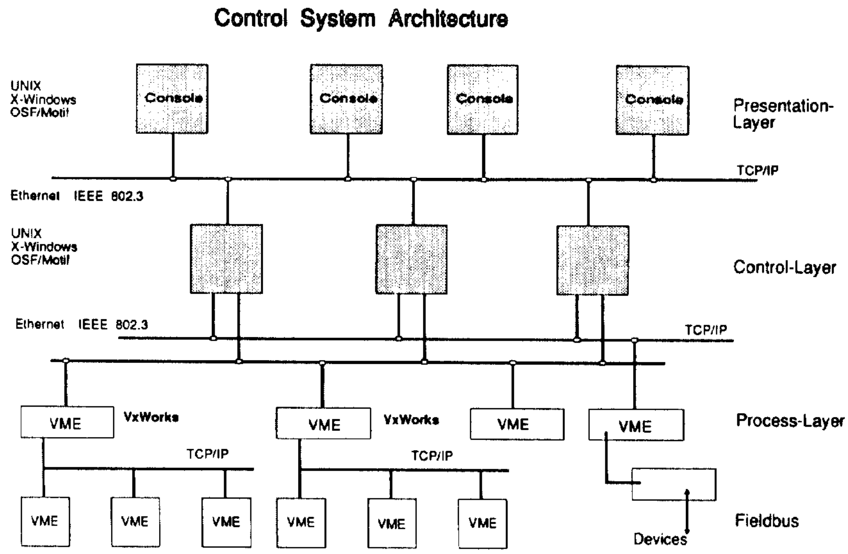

Figure 1
ROSY Control System Architecture

acts as a mirror image of the accelerator state. In addition, there are one or several server computers in the control layer, which provide disk storage, relational databases, printing and other central functions in the network.

The **process control layer** performs data reduction and runs control and measuring tasks. It is built of VME based components with MP68030/40 CPUs assisted by dedicated image processing boards and digital signal processors for fast beam diagnostics and digital feedback systems.

The **fieldbus layer** interfaces all the devices of the accelerator complex which do not require high data throughput and connects them to the process control layer. It is realized through low–cost VME components and/or possibly by use of a fieldbus system which has established itself in industry.

The process control and the fieldbus layer together form the **process system**. For both layers of the process system a real–time operating system will be used which must have excellent networking capabilities. At the present state of evaluation, the "VxWorks" kernel [4] is our favourite choice. All VME crates of the process system are diskless; they boot over the network from the computers of the control layer.

The **communication system** between the upper two layers and the process system is based on Ethernet (IEEE 802.3). The physical media is optical fibre; the topology of the network will enable a subsequent upgrade to the FDDI standard. The consistent realization of the process system with VME components and a uniform operating system allow for a homogeneous communication system based on standard protocols (TCP/IP) for the complete control system. The remote inter–process communication on all layers is realized through synchroneous and/or asynchroneous message exchange. High bandwidth data paths will be realized exclusively by using TCP socket data transfers, accompanied by data compression whenever necessary (e.g. for images and BPM signals).

4 Software

The efficiency and flexibility of a control system is mainly determined by its software. The software of the control system performs tasks which in many ways resemble the duties of a *distributed operating system*. The results arising from research in the field of distributed systems are therefore fundamental for the design of such an accelerator operating system [5][6].

4.1 Process Applications

The process system contains applications for data acquisition, equipment control, monitoring and alarms and for complex real–time tasks like feedbacks and ramping. Each application consists of a set of one or more concurrent threads synchronized by the VME operating system kernel. These applications send data to the control layer in regular intervals (e.g. tune monitoring), triggered by observed parameter changes (e.g. status conditions) or perform a task on request (e.g. image acquisition and processing).

4.2 Rule Engines

Each control computer runs a "rule engine" (i.e. a set of processes fed with patterns of accelerator parameter changes) which elaborates abstract rules and correlates machine parameters. A set of rules will handle the algorithmic mapping from hardware dependent parameter sets to machine physics parameters. Other rules will implement heuristic recipes for easy management of complete subsystems. Rules may be activated or deactivated during normal operation.

4.3 High Level Applications

User oriented applications which run on the presentation layer have a common graphical user interface, built in accordance with the OSF/Motif guidelines. They consist of graphical objects (panels, menubars, knobs, etc.) of the Motif and X11 program library, which provide a completely event driven usage of the application. The structure of the control system allows for application programs to transparently access any of the controlled parameters through a common application interface which hides details of the control system from the application programmer.

4.4 The Man Machine Interface

The man machine interface (MMI) is the interactive tool from which the individual components of the ROSY accelerator complex are controlled. In order to avoid confusion and to minimize the learning time, the MMI builds on ergonomic and logical concepts which allow for an intuitive understanding of its operation and of the operation of the devices it controls.

The interaction between the user and the MMI is based on virtual navigation through the synoptic which is built as a plan view of the accelerator complex, using PHIGS for vectorial graphics. The elements to be controlled are represented by graphical objects which resemble their real appearance, arranged in accordance with the topology of the whole complex.

Virtual control panels allow users to operate on the graphical representations of a large set of devices like switches, knobs, sliders, digital and analog indicators, whose behaviour is equivalent to that of the real instrumental devices. The panels can be generated interactively by means of a control panel editor in a menu driven way without writing a line of code. The connection with the online database and the underlying servers on the lower layers is automatic and completely transparent.

4.5 Databases

Each computer of the control layer is managing a memory resident online database representing one part of the accelerator complex. The set of online databases on the individual computers is linked via horizontal communication paths, such that only a single, distributed database is seen which allows for transparent access to all the informations pertaining the accelerator. The relation of given parameters to individual computers is not explicitly seen by high level applications and process layer software alike.

The offline storage of machine data is performed by a relational database system based on SQL. The control system relevant parts of ROSY are completely described by the offline database.

5 Acknowledgement

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6 References

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