STATUS REPORT OF THE MAMI CONTROL SYSTEM [1]

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Abstract

The basics of the MAMI control system were designed in 1981 and have survived some generations of computer operating systems and hardware platforms. Thereby the control system has been developed in a way to be independent of the operating system and to be usable in inhomogeneous networks. It runs on many Unix-flavors, VMS and also Windows NT systems. This has been achieved by a name-based connectionless process communication system, encapsulating the operating system dependencies. All the control system software has been built on this basis, forming something like a “distributed computing environment”, making it possible to run in principle each control process on any computer of the network. The distribution of the processes in the network is on-line configurable without interference with the accelerator operation. The MAMI control system contains among other things a control GUI, based on a commercial package for animated graphics, fast touch-panel and knob systems, an interpretive control language to program complex actions and a flexible supervising tool generating global information for status displays, warnings or emergency switch-off actions. The extension of the MAMI accelerator by a fourth stage (double-sided microtron) to be built in the years 2000 to 2003 requires a further expansion of the existing system.

1 INTRODUCTION

MAMI (*Ma*inz *Mi*crotron) is a normal conducting electron accelerator with an output energy up to 880MeV at 100µA continuos wave. Its excellent beam quality and the high reliability in operation[1] enables a lot of high precision experiments in nuclear physics. MAMI consists of three cascaded race-track microtrons feeding an extensive beam transport system to four different experimental facilities. A c.w. linac serves as injector together with three electron guns, one producing conventional thermionic and the others polarized electrons. One of the polarized guns is equipped with a complicated two plane spin rotator system. The first two microtron stages with an output energy of max. 180 MeV were built in 1983 and operated for 5 years for nuclear physics experiments. Since 1991 the 3rd stage and the beam lines are in operation for experiments at full energy range from 180 to 880MeV. Therefore the control system is now in principle 15 years old, but has grown and was improved together with machine extension and with development of control- and computer technology. This resulted in a control system being independent of the computer operating system and having a great flexibility in configuration and hardware architecture.

The basis of the MAMI control system is a process communication system (IPC) with an object-name based addressing scheme. It enables the asynchronous interchange of arbitrary data-streams between the processes, called “messages”, and makes also some typically operating system features available like e.g. timer interruptions. The IPC is implemented by using shared memory for local communication inside a computer, but network demons take care for the transport between computers. The addressing information needed for routing the messages are loaded and updated online from the central database in the network. Therefore the structure of the computer network is totally hidden from the communicating processes.

The distribution of the control system processes over the network is also determined by information out of the online database and is controlled by a supervisor process, residing on each of the computers, creating or terminating the other processes as demanded by the database contents. This architecture is one of the requirements for the online configuration property.

IPC and process management is available for OS9, the most UNIX-flavors, for VMS and also Windows NT. As shown in Fig. 1, the MAMI control system presently contains computers with DEC-Unix, Linux, Solaris, VMS and Windows NT.

2 HARDWARE

For historical reasons a considerable part of MAMI is controlled with CAMAC systems. In many cases modules with 16 bit parallel input/output were used. In the last years VME-bus and Interbus-S (as long range field-bus) have been introduced, enabling the connection of all new installations. To provide flexibility in device connection, special VME- and Interbus-S-moduls have been developed in a way to be connector-compatible to the ancient CAMAC modules. Additionally a wide range of devices are controlled via RS232 by using smart line servers (RS232 MUX in Fig. 1).

The front-end computers are VME-crates with a CPU running Unix (for the fourth stage we are thinking about using also Windows NT). The CAMAC system is controlled via a converter from VME, the Interbus-S via smart controllers alternatively from VME or Ethernet.

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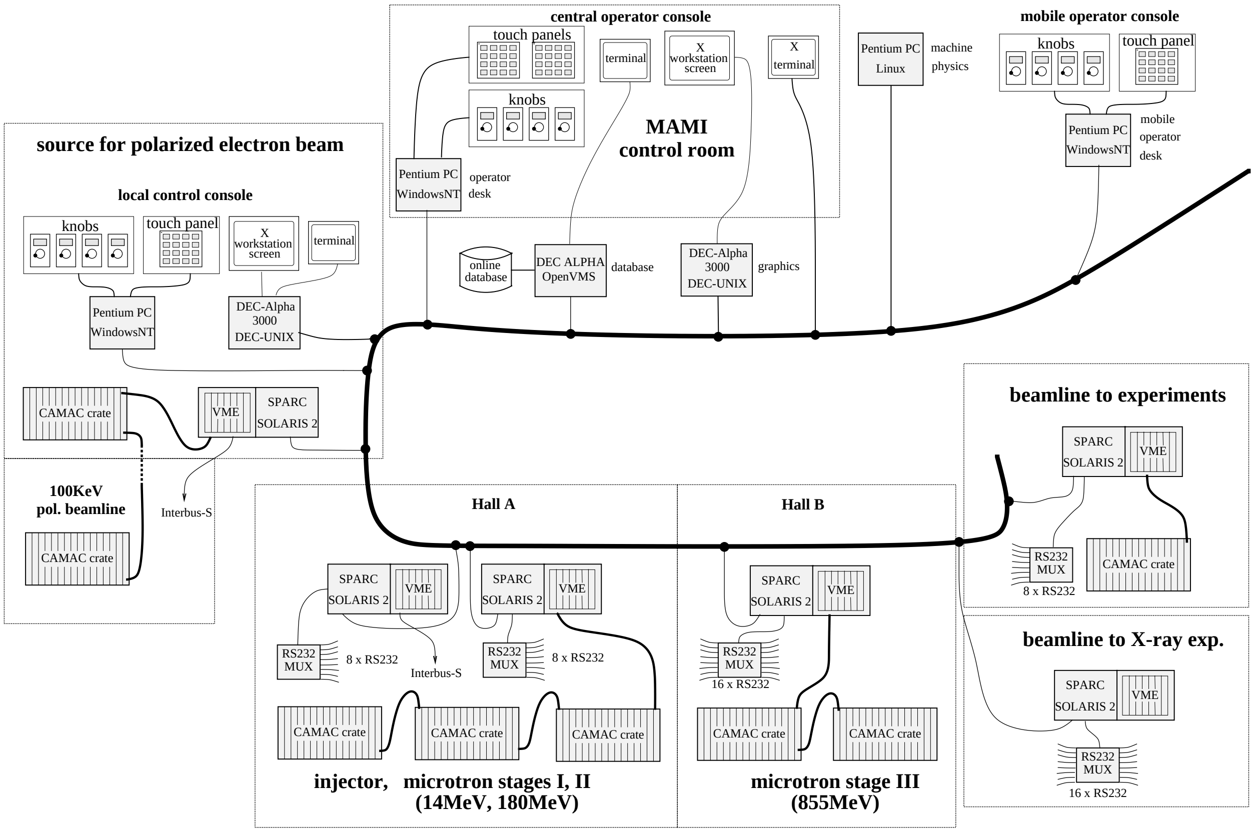

Figure 1: Topology of the MAMI Control System

The central online database resides (still) on a DEC-Alpha-workstation under VMS. The operator interface consists of DEC-workstations under Unix, running the graphical user interface, and Windows NT stations, serving as touch-panels and controlling the knobs for analog data input.

3 HIERARCHY

The control system is structured strictly hierarchically. The highest level represents the man-machine interface, containing also a high level control language interpreter. In the middle there reside the regulation and handling processes and on the lowest level are the hardware control processes.

3.1 Hardware level

The hardware control processes may be structured in sublevels. However, on the top of this level there is an uniform and rather simple communication layer, where data settings via IPC-messages are typically done in physical units (like e.g. Amps or mrad) and switch-on or switch-off orders are no hardware primitives, but comprise a full setup of the object to be controlled. This essential feature represents an abstract communication interface for all processes in the levels above. They usually need to know only the name of an object or device to send simple orders to it, which may expand to quite complex actions on the hardware devices.

3.2 Regulation and handling

Here are located control programs for regulation (e.g. magnetic field stabilization), periodical device checkups or programs to combine or connect objects of the lower levels together (e.g. combine three quads to a triplett with specific properties, or connect an element with an operator knob). Also the logging of data on file is done by processes on this level.

3.3 Man-machine interface

For machine operating a graphical user interface with synoptic drawings, a touch panel and a Basic-like command language interpreter are available. The GUI was implemented using the commercial package “Gipsy”, which is a derivative of “DataViews” (VI-Corporation), and available for many operating systems [2]. For data-input digital knobs with small display-units showing name, status and actual value of the element are in use. These knobs are an in-house development and turned out to be the most favorite control device for adjusting analog values.

The interpreter was developed using a compiler generator and is used to perform frequently used compounded operating action sequences. It is also often used by the machine physicist to manage complicated measurement sequences.

4 DATABASE

The on-line database of the MAMI control system contains the data necessary for message delivery, for controlling the accelerator components and also all actual machine data. To each real or virtual element in the control system, identified by its unique name, are associated a computer node, a control program and a program dependent data structure describing the properties of the object, for example hardware address, scaling, actual value(s) and its actual status. The data are typically used and updated by the associated program. A special database editor enables the creation of this data structures together with a detailed description of variable names and data-types.

Also integrated into the database program is an event mechanism making possible the monitoring of selected variables of the data structures for other programs. This feature is used by supervising programs described later on and by the graphical status display.

The whole database can be saved to file. This is done for archiving purposes and data analysis, but is also the typical way to prepare the restoring of the status of the whole machine or a part of it at a later time. To establish the latter, a machine setup program reads the data structures from the saved file and sends them to the object names belonging to them. The attached programs setup the objects/devices into the given status. Selection of the objects to be restored can be done using wildcard names – the main reason for having strict naming conventions for the accelerator components.

5 SUPERVISION

The event mechanism of the database enables programs to supervise values in the database and in turn the status of the associated objects, especially the machine components. In such programs typically the status of several objects is combined together to a resulting status, which may either be used to display something like a system-status or to prevent dangerous or undesired conditions in machine operation by intervening automatically. The algorithms for combining the data are described in an easy readable dependency description in a formal language, which is compiled by a preprocessor into a C-program. The indirect way via the formal language was chosen to enable machine operators to understand easily the interventions of the supervising programs, which may be not clear for everyone in every situation.

6 ANNOUNCEMENT SYSTEM

There are a lot of text messages generated by the control system programs to describe problems as precise as useful, especially if they concern device specific failures. The announcement system is responsible for the routing of this messages. It selects the operator console(s) on which the text message is displayed and prevents any overrun of internal buffers or of display output by frequently repeated messages. In addition operators can choose the language in which the messages are displayed. The operator console to show this output is determined in dependence on the name of the controlled object via a wildcard selection mechanism controlled by database data, so that error messages concerning special parts of the accelerator plant may be displayed on specific consoles. The system for polarized electrons, for example, is typically operated by another staff than the machine operators and therefore controlled from a different operator desk.

7 FUTURE EXTENSION

The MAMI accelerator will be extended by a fourth stage, which should be finished in ca. the year 2003. This fourth stage will be a double-sided microtron [3], raising the output energy to 1.5GeV. Therefore an expansion of the control system is necessary, whereby also some renewals should be done. Some control routines are still written in Fortran, for historical reasons, and the database program is running only under VMS. Especially the latter point is a considerable restriction for the portability of the whole system and will be changed by using a commercial database and connect it to a run-time database process, which delivers data as fast as possible. Due to the scalability and the portability of the main parts of the control system, it will be no problem to extend it with new computers and new hardware connections, to be able to operate the planned accelerator stage.

8 SUMMARY

Due to the continuous development over many years the MAMI control system has been adapted to many software and hardware environments. This long experience resulted in an easily understandable and a very stable running system. The need for permanent extensions due to the enlargement of the accelerator complex conserved the scalability of the system and made features like on-line maintenance necessary. The maintenance of the system was simplified and can be performed with a minimum of manpower.

Major extensions will be done in the next three years to enable the control of the new accelerator stage to be built.

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