NEW INTEGRATED CONTROL SYSTEM OF IHEP ACCELERATORS COMPLEX

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Abstract

The paper outlines the IHEP accelerators complex and its controls problems. The structure of the three layers Control System hardware is presented. Layout of software realizing the distributed data base approach is considered. Control network organization with remote access options using two types of modem is outlined. General timing system synchronizing equipment controllers with the accelerators events and based on MIL1553 protocol for distribution of the timing messages is presented. Special attention is paid to adaptation of the existing technological equipment, manufactured long ago, to the Control System. Four categories of unified interface with a great variety of such an equipment is described. The present status and further activity plan are presented. Main results and problems of the first Control System runs are discussed.

1 INTRODUCTION

The IHEP accelerators complex (U-70) and its original controls were outlined earlier [1]. The creation of new integrated control system (U-70 CS), based on the modern unified hardware and software principles and products, is aimed at increasing the efficiency of the U-70 as an instrument for the high-energy physics. This paper presents the main U-70 CS project solutions and first results of their realization. The design study of the project was done in collaboration with CERN [2].

2 U-70 CS HARDWARE STRUCTURE

The control system is built as a distributed one with a classical three level hierarchy. The Console layer consists of computers and X-terminals for operator interaction and different servers (data base server, file server, console server, etc.). Ethernet links the components of this layer with each other and with the Front End Computers (FEC).

The FEC layer consists of a few VME crates, each of which houses a single-board computer (SBC) based on the Motorola MC68040 microprocessor and one or two MIL1553 Bus Controllers. The latter provide communication with Equipment Controllers (EC) through MIL1553 Remote Terminal. The function of the FEC is mainly traffic control between the upper and lower U-70 CS levels.

The EC layer, which consists of several tens of equipment controllers, executes the actual real time control and acquisition work. The EC is a Multibus-1 crate housing a set of so-called system modules (the Intel 80186 based SBC, the MIL1553 Remote Terminal, the Timing Message Receiver) and a set of unified I/O modules which form the interface with the Process Equipment.

3 CONTROLS NETWORK

The network has a two-layer architecture using 100 Mbit/s Fast Ethernet as a backbone and 10 Mbit/s for the rest of its infrastructure. Ethernet switches are used to provide 100/10-Mbit/s connectivity and separation of local traffic. The backbone links two network nodes (the Servers Hall and the Main Control Room) which are situated in different buildings. All servers are directly attached to the backbone while X-terminals, FECs and other nodes form the 10 Mbit/s layer.

Two remote sites (U-70 main power supply, U-70 beam recapturing station) and several remote access points (ground part of U-70 RF stations) are connected to the network by means of serial links and modems (2 Mbit/s and 64 Kbit/s), which are driven by so-called “remote servers”. Such a solution allows to utilize existing cabling and hence minimizes the cost of the network installation.

In order to provide reliable communications between the CS computers the network is isolated from the common IHEP and departmental office networks. The only way to access the control system from outside is via a gateway. Thus the network is effectively protected from uncontrollable external traffic and/or from unauthorized access to its resources.

4 GENERAL TIMING SYSTEM

For execution of the real time controls tasks, the ECs are supplied with timing information including a) general 1 kHz clock, b) accelerators cycle events with dedicated data and c) special signals providing PPM mode of operation.

This information is distributed in the form of encoded timing messages. For physical transmission the MIL1553 standard is used. The basic unit of the timing information stream is a frame of 1 ms duration. Every frame is divided into 10 time slots, each of which carries one time message (command and data word of the MIL1553 standard).

Main components of the General Timing System are Timing Message Generator (TMG) and Timing Message Receiver (TMR). The TMG encodes the input timing information, forms a stream of timing messages and sends it into the common transmission channel. The TMR plugged into the EC crate decodes and processes the messages. It outputs the 1 kHz clock, interrupt request signals and commands to change the accelerator

regime parameters.

5 PROCESS EQUIPMENT INTERFACE

The U-70 process equipment, which has to be adapted to the new control system, represents a large number of devices with a great diversity of functionality, mechanics and electromagnetic background conditions. In spite of this diversity, the adapting electronics have to be unified and simplified as far as possible in order to reduce the price of their development, production and maintenance. To achieve this goal in the most economical way the process equipment is classified in four broad categories, each of which allows a fairly uniform interfacing:

Category A is characterized by a wide range of the variable I/O requirements for signal processing. Such equipment (for example, beam monitoring devices) is interfaced to the EC by means of a corresponding set of unified I/O modules composed in accordance with the control task and plugged into the EC crate.

Category B includes the equipment where existing computerized controls are based on SUMMA (an IHEP version of the CAMAC). Such equipment is linked to the EC by means of a Multibus-1/CAMAC interface module (Branch Driver) plugged into the EC crate.

Category C is characterized by well-defined and constant I/O requirements for signal processing. In most cases the equipment of category C represents a number of racks distributed rather far from each other. Such equipment (for example, power supplies of the magnetic systems) is interfaced to the EC by means of unified embedded microcontrollers linked via a RS485 bus to the Bus Controller plugged into the EC crate.

Category D comprises standard industrial devices used as the measuring means or as the functional components of the technological systems. This equipment is interfaced to the Control System by means of personal computers with GP-IB cards. These computers of minimum configuration are linked to the CS Network.

6 SOFTWARE

The software is built using a distributed data bases approach. The basic concept discusses an accelerator as a technological process which may be presented by a limited set of parameters. Each parameter changes some predefined number of states during the accelerator cycle. All states of all parameters are kept inside of specialized real time distributed data bases and are seen as an informational model of the technological process. Each application deals with this model only. Figure 1 shows the general software layout consisting of four architectural elements: distributed DBs, user interface tasks, data processing tasks and I/O tasks. I/O tasks run in the equipment controllers, all other run in the work stations. More details of the software architecture are described in [3].

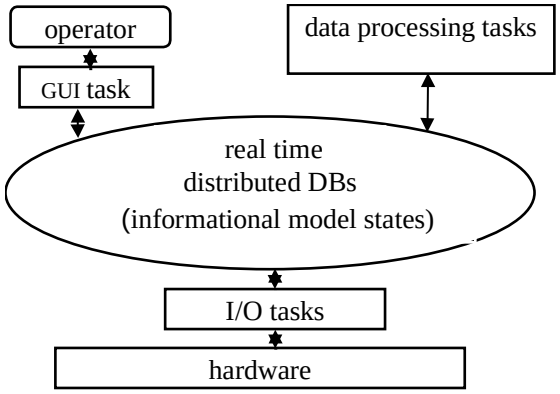

Figure 1. General software layout

The control system supports on-line up to 30 specimens of the informational model, which are saved on operator request and contain measurements and settings. An operator may observe, compare and restore any specimen as a current state of the technological process.

7 U-70 CS PROJECT REALIZATION

In brief, the project realization plan looks as follows:

- Creation of basic components of the CS hardware and software– by the end of 1998
- Integration of the old computerized controls into the new U-70 CS – by the end of 1999
- Conversion of the old manual controls into the new U-70 CS – by the end of 2000

At present all system components are developed and produced, namely, the EC system modules with multitask real time monitor, the General Timing System hardware and software, the EC/FEC MIL1553 software communication means, the CS Network, the distributed DB infrastructure, the user control tools and the CS computer centre.

All these products were tested and put into operation at the U-70 Booster under real working conditions. For the new controls, the necessary I/O modules were developed and produced. Besides that the first set of application software was written and debugged. As a result the Booster old controls based on obsolete EC1010 computer and M80 microcontrollers were replaced.

The hardware and software commissioning caused extra accelerator down time. This is illustrated below (the percentage with respect to the total time of the run):

1997	II run	4.3%
1998	I run	1.8%
1998	II run	< 0.1%
1999	I run	0.0%

The main reasons of the down time are as follows:

Second run of 1997

- Failures of the home-made MIL1553 Remote Terminals. To increase reliability the module design was corrected.
- Malfunctions and overloads of the office network used temporarily for the controls. The U-70 CS network was created later.
- Debugging of the system and application software during the run since this is the only way for the final commissioning.

First run of 1998

- The Quick Data package was not adequate for the real conditions of the information exchange in the U-70 CS. Necessary corrections were made for this ready-made product.

The negligible time losses during the last runs do not mean that the new Booster controls are perfect and the users are completely satisfied. After the reliability problem has been solved the next task is to develop and extend a user-friendly interface, in particular, to enrich the graphic presentation options based on the XRT software product.

8 ACKNOWLEDGMENTS

The authors are grateful to CERN specialists H.Lustig, F.Giudici, B.Kuiper, G.Daems for the fruitful collaboration and their active participation in the Draft Design Study. We thank also Th.Blumer (PSI,Villigen), W.-D.Klotz (ESFR,Grenoble), R.Raush (CERN), who participated in the Review Meeting as controls experts, for useful discussions and recommendations.

9 REFERENCES

[1] V.Komarov et al. “Upgrading of the U-70 complex controls”, Proceedings of the ICALEPCS’95, Chicago, Illinois, USA, 1995, Vol. 2, p. 930.

[2] V. Komarov et al. “Draft Design Study for the Control System of the U-70 Complex”, IHEP&CERN, CERN internal note: PS/CO/Note 96-26.

[3] V. Voevodin “Software Architecture of the U-70 Accelerator Complex New Control System”, this proceedings.