ACCELERATOR CONTROLS IN KEKB LINAC COMMISSIONING

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Abstract

In the commissioning of KEKB e^- 8GeV / e^+ 3.5GeV linac the accelerator control system was much improved, since reliable operation of the linac is indispensable to achieve the higher luminosity at the ring.

Many controllers were installed to manage newly installed accelerator equipment and beam instrumentation. Parts of the optical FDDI/Ethernet network system and the main computer system were made redundant as well as control services in order to provide reliable operation.

The database is made of simple files and homemade hash routines. The source files of the database are shared between the control computers and office computers to ease the update. Control software is based on RPC over the network. Although many different kinds of controllers are utilized, RPC servers hide the differences.

New operator interface panels were introduced for the X-Window environment to be used in both the linac local control room and the KEKB main control room. They were developed with script languages for rapid modifications during the commissioning, which included Tcl/Tk, SADscript and others. The system serves stable linac operation, and many application programs are being developed on top of it.

1 INTRODUCTION

The KEK e^-/e^+ linac has been reinforced to inject full energy beams to the KEKB asymmetric B-factory with 8GeV e^- and 3.5GeV e^+ [1].

Although the control-system architecture didn't change, the number of operation points became several-times larger, and now four beam operation modes (KEKB e^-, e^+, PF e^- and AR-PF e^-) must be switched with very different beam and equipment parameters [2, 3].

2 LINAC LAYERED CONTROL SYSTEM AND NETWORK

The design of the linac control system was rejuvenated in 1993 [4, 5]. In the new control system, international and de facto standards, such as Unix, VME and TCP/IP, were employed, while many of the old local device controllers had to be maintained. The control software was rewritten so as to build layered equipment services utilizing a homemade remote procedure call (RPC) scheme.

2.1 Field controls

The computer network for controls comprises an FDDI and about 50 Ethernet network segments, which are isolated from the laboratory-wide network by a firewall. Although the FDDI and Ethernet networks around the main control room use twisted-pair cables, the connections to local field controllers are now based on fiber-optic cables (10Base-FL Ethernet) in order to eliminate noise from the high-power klystron modulators in pulsed operation. A star-like topology was employed to localize any problems and to ease trouble-shooting.

Currently, the number of 10Base-FL nodes is just above 200. They are connected with one of 33 10Base-FL repeater stations, which are spread along the 600-meter linac building, and then concentrated into FDDI-10BaseFL switches at the main control room. While the 10Base-FL connection between the field controllers and the repeater stations are single, those between the repeater stations and the central switches are made fault-tolerant by adopting redundant switches and redundant transceivers, since any problem at this level is severe.

For local device controllers, no standard was defined. Once it was considered to have VME computers as standard device controllers. However, while we have many old controllers which are already about 20 years old, every year new technologies are revealed. Thus, from our experience, it's not practical to decide on a standard. Actually, it costs much manpower to maintain a standard for 20 years.

Instead, we defined criteria, which require that each local device controller should at least speak the UDP protocol and be diskless, if possible. If the controller is intelligent, the UDP version of our RPC protocol is installed on it. Old controllers are indirectly connected to the RPC network environment through VME's.

2.2 Central-control architecture

Unix computers consist of a computer cluster and isolated computers, which are also operated to be fault-tolerant. They are mainly based on DEC Alpha architecture, and a cluster software called True Cluster is installed. They carry most of the upper-layer control tasks.

Control services on Unix computers are designed to be accelerator-equipment oriented. Upper layer software

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serves logical equipment controls hiding physical details. Since several different controllers per a kind of equipment were developed over a period of 20 years, every effort has been made to carry hardware-dependent processes in the lower layer software. Most lower and upper layers communicate through the UDP version of the RPC in order to recover failures reliably, while the TCP version is used between the upper layers and the application clients.

Each layer uses a simple memory-resident hashed database to process controls. Depending on the response time of the underlying layer, a layer may cache information, while methods to bypass the cache are also provided [7].

Besides running control-process software, Unix servers also support many network services, such as file services (NFS, NetBIOS, AppleShare), a network firewall, name resolutions (DNS, NIS), remote booting (BOOTP, DHCP, TFTP), time synchronization (NTP), failure reports (SNMP, SMTP), routine reports (HTTP), printer services (lpd, AppleTalk, NetBIOS) and office mail (SMTP, POP3).

Those services are run redundantly and are utilized from a number of control computers. They are used on the office network as well in order to exchange information quickly between engineers, the control group and the commissioning group. Essentially, at the beginning of the commissioning the database was updated every day using these services.

3 LINAC UPGRADE AND CONTROLS

For the KEKB project, the linac beam energy was upgraded from 2.5 GeV up to 8 GeV; also, 3.5 GeV positrons are generated [1]. In order to accomplish this, energy doublers (SLED) were employed and the length of linac was extended by 50 percent; the number of accelerator devices was also increased by roughly 50 percent.

Many old controllers for them, which were designed about 20 years ago, could not be reproduced any more, mainly because of production discontinuance of their components and company closures. More functionalities were also eagerly required. Thus, new controllers were designed based on the criteria of a UDP connection and being hard-disk-less.

New controllers were designed utilizing VME, VXI, CAMAC, PC and PLC technologies, depending on the needs specific to the corresponding devices.

Many of the newly designed simple controllers employed PLC's (Programmable Logic Controller). Until recently, its performance and remote connectivity did not meet our requirements. However, it just satisfies our needs for simple controllers; further, its cost-performance is appealing. For example, the response time of a remote control of several input/output ports over a network is about 20 milliseconds. Although this is 10-times slower than modern VME processors, if large data processing is not necessary,

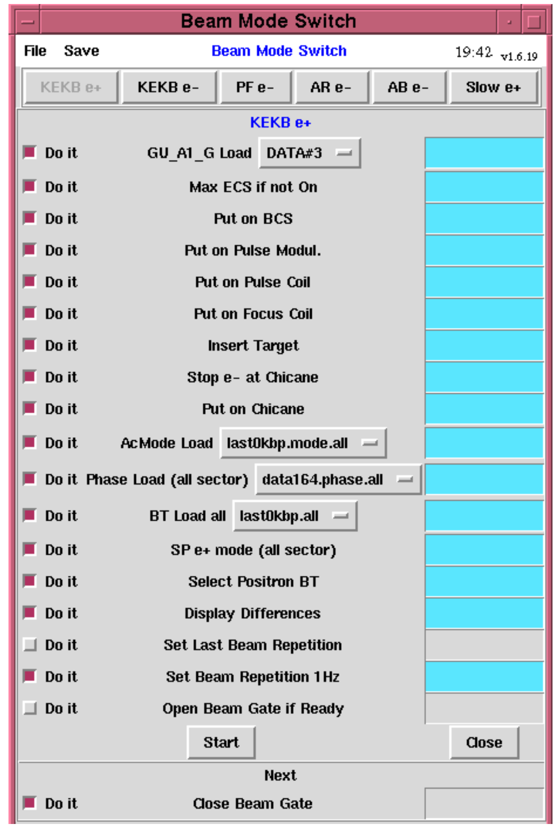

Figure 1: Beam-mode switching panel enables automated beam-parameter replacement, changing a number of equipment parameters. Some of them are processed in parallel and others sequentially.

a PLC is adequate for simple controllers [6].

Upper-layer software had been designed to be independent of the lower layers. It was, thus, relatively easy to integrate new lower layer software for new controllers. At least the RPC interfaces between the upper layer software and clients were kept unchanged, although the protocol was independently extended to accommodate new needs.

4 COMMISSIONING SOFTWARE ENVIRONMENT

Originally, Microsoft Windows and Visual Basic were considered to be an application development environment. However, we didn't have manpower to maintain the gateway to the control system, and to make new equipment in the accelerator and new features in the control system available.

Thus, we had started to use the following environments: Tcl/Tk and RPC for simple operations, which was originally prepared as a test tool for the control system, and SAD/SADscript/Tk for beam operations, which was designed for advanced beam physics. Both of them have interfaces to the control system and the Tk graphical widgets. With SADscripts, we use both the direct RPC access to the

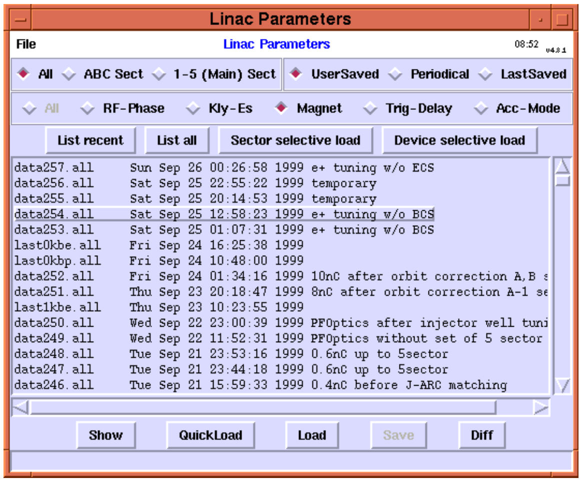

Figure 2: Parameter load-save panel with features to select many options. These include device selection based on the location; also, database is shared between many applications.

linac and the EPICS channel access (CA) through the linac CA server, which was developed using the EPICS portable CA server toolkit.

Under those environments, common routines are provided as libraries, such as a control-system RPC interface, default menus, software error recovery, software error logging, software parameter save/restore, debugging facilities, runtime software inspecting facilities, inter-application communication, etc. Those implementations were relatively easy, since those languages are interpretors.

5 COMMISSIONING APPLICATIONS

There are about fifty application programs registered in the linac commissioning software launcher, which have been modified daily based on the needs in the commissioning.

They include a beam-based BPM re-calibration, an on-line buncher simulation, an emittance measurement and matching, an isochronous and achromatic correction to the arc section, an adaptive beam-orbit correction, a downhill simplex optimization and linac feedback systems.

Some of them are shown in Figs. 1, 2, 3. Also feedback systems for linac commissioning, which utilize the same software framework, is discussed elsewhere [8].

6 CONCLUSIONS

The combination of the linac control-system architecture and the commissioning software environment greatly improved the linac operation and it could meet the linac commissioning needs. It could even accommodate applications which were not included in the original design.

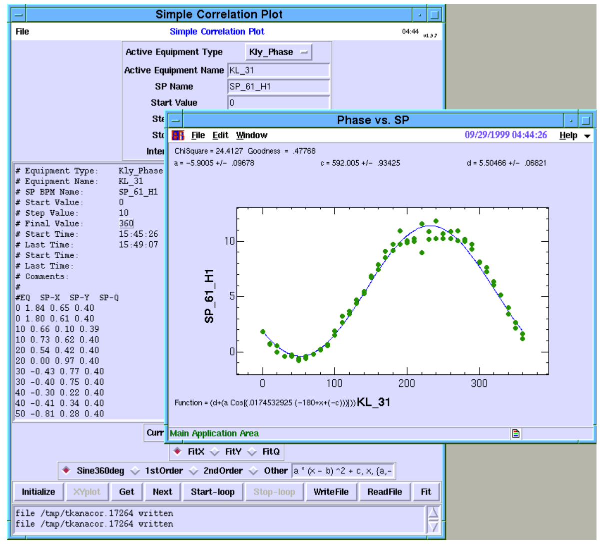

Figure 3: Active correlation plot automates equipment parameter optimizations. It can fit acquired data with arbitrary functions. A passive version of the correlation plot enables one to find multi-parameter correlations, which are not known beforehand.

7 ACKNOWLEDGMENTS

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