STATUS OF THE KEKB ACCELERATOR CONTROL SYSTEM DEVELOPMENT

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INTRODUCTION

KEKB is a 5-year project started in 1994 to convert the existing TRISTAN electron-positron accelerator/collider into an asymmetric one.[1] TRISTAN is a three-stage cascade accelerator/storage ring with a 2.5Gev electron/positron injector Linac, 8GeV Accumulation Ring (AR) and 33GeV accelerator/collider Main Ring (MR). For the KEKB project the Linac will be upgraded to provide intense 8GeV electron and 3.5GeV positron beams to inject directly into the KEKB rings. The KEKB rings, the High Energy Ring (HER) and the Low Energy Ring (LER), will be installed side by side in the tunnel where the TRISTAN MR is at present. The TRISTAN MR will be shut down at the end of 1995 and the equipment will be removed from the MR tunnel. As the 8GeV AR will not be used by KEKB, it will be used as a synchrotron light source and for accelerator experiments. At present, TRISTAN is controlled by a system using mini-computers and CAMAC [2], but modern technologies will be introduced for KEKB controls. To save money and manpower, the CAMAC system will be reused after rearrangement. The present control system for TRISTAN was designed about 15 years ago and has become very hard to maintain. It is clearly important to have a good control system for a modern intense beam asymmetric collider. The quality of the control system required by KEKB is much higher and the quantity greater than that of the present system. However, the progress in the fields of computer hardware and software seems to give us the chance to have a more sophisticated control system and to make it possible for us to construct a control system which satisfies requirements in both quality and quantity. The preliminary design has been reported previously [4].

FUNCTIONAL REQUIREMENTS

The control system design must be looked at from as many points of view as possible. Usually the suppliers of the system and the users tend to have different points of view. Therefore, we first started to review functional requirements of the control system for the KEKB collider. The hardware groups that install the accelerator components to be controlled want to monitor magnet current values, voltages of the power supplies and so forth, and if a failure occurs they want it to be reported and recorded as soon as possible. The operations group wants the recording of the operations sequence of the collider and to have tools to analyze the previous operations and make correlations between parameters and measured values for tuning purposes. Accelerator physicists need the connection between beam monitoring, simulation and beam correction systems. The controls group itself has its requirements.

The principal functional requirements are as follows:

1) All the data that can be taken should be taken.
2) All the data taken should be saved for later analysis
3) All the operations should be recorded for later inspection.
4) All the machine parameters and data about the machine components should be saved in the database.
5) The control system should be operator-friendly.
6) The programming system for application programs should be programmer-friendly.
7) The overall response time to an operator's request should be less than a few seconds, ideally one second, unless the progress of the process is indicated.

CONSTRAINTS

The KEKB collider is a reconstructed machine and there are many constraints in constructing its control system economically and effectively. The first of them is CAMAC. We have already accumulated a large number of CAMAC modules in the TRISTAN control system and CAMAC is still thought to be the only well-defined standard for interface modules which can be used for process input/output. The old mini-computers will be removed from MR sub-control buildings and the CAMAC equipment configuration will be redone and some new CAMAC modules will be added. On the other hand, there is no constraint to introducing a new software environment, because all the application programs will be new.

The final commissioning of KEKB is scheduled to take place in 1998, so the control system should be installed at least one year before then. The basic system for the hardware and software development will be installed at the beginning of 1997. It will include some workstations, VME computers and X-terminals for the operator's consoles. Another constraint is that there are only a dozen people in the KEKB controls group.

BASIC DESIGN CONCEPTS

Considering the requirements stated above and the restrictive conditions, the basic concepts are to use:

1) the so-called Standard Model for the accelerator control system.
2) international standards for the interfaces between the three layers, to facilitate later upgrading and maintenance.
3) international standards such as CAMAC, VME, VXI and GPIB as the interfaces between the control system and the equipment to be controlled.
4) products either from international collaborations or that are commercially available, to minimize the manpower and effort required
5) the object-oriented technique or abstraction to hide the hardware from application programmers,
6) high-speed networks to connect the computers with each other to get a quick response,
7) the linkmen system as in the construction of the TRISTAN control system, in which the linkmen make the equipment database and code device drivers for the application programs because they know the equipment best.

Finally, we decided to use EPICS as the KEKB control system environment, and we joined the EPICS collaboration.

SYSTEM ARCHITECTURE

The control computer system is divided into three layers - presentation layer, equipment control layer and device interface layer, as shown in Figure 1. The first two layers are divided functionally but connected with each other through a high-speed network such as FDDI. This is because the network traffic between the presentation layer and equipment control layer computers is expected to be dominant. There is also a possibility of adopting a distributed shared-memory network to obtain fast data transfer and event transmission among the computers. The presentation layer which is called an Operator Interface (OPI) in the EPICS world is composed of several workstations and about 6 to 10 X-terminals used as operator consoles. The functions which the workstations run can be executed by a UNIX server which has multiple processors. The main network is an FDDI ring that has a node at each local control building; there will also be an Ethernet segment in each building. The equipment control layer consists of about 60 to 80 VME Input/Output Controllers (IOC) distributed around the KEKB rings. Each IOC will be allocated to a hardware group to avoid conflicts among groups or users. The final layer, the device interface layer, has standard modules such as CAMAC, GPIB, VXI, etc. There will be a special interface for controlling the magnet power supplies.

Presentation Layer

OPI, the presentation layer, will include operators consoles, database manager, simulation computer, alarm generation/recording, data logging, display and a gateway to the KEK in-site network. There will be workstations running UNIX. X Windows, MS Windows and Windows NT are candidates for the operators console. The database manager computer will keep all the information concerning KEKB including machine parameters, equipment specifications, location, and so on. The simulation computer will be used for accelerator physics simulation calculations for such purposes as orbit correction. Faults in the equipment will be monitored by each IOC and reported to the alarm computer for broadcasting and recording purposes. The data logging computer will collect data from various equipment control computers for later analyses. The display computer will display data and transmit information over the KEKB site through the CATV network and other media. There will also be a gateway computer to connect the KEKB control computer network with the KEK laboratory network to make it possible for the accelerator department staff to reach KEKB collider equipment from their offices.

The software environment required for this layer is very important for the whole system. The fundamental functions: to display status and measured values graphically, to control each piece of equipment etc., should be supported from the start of installation of the machine equipment. The programmer-friendly interfaces must be provided for the accelerator physicists to make application programs easily. And it is also important to have a very efficient data retrieval and analysis system via the database.

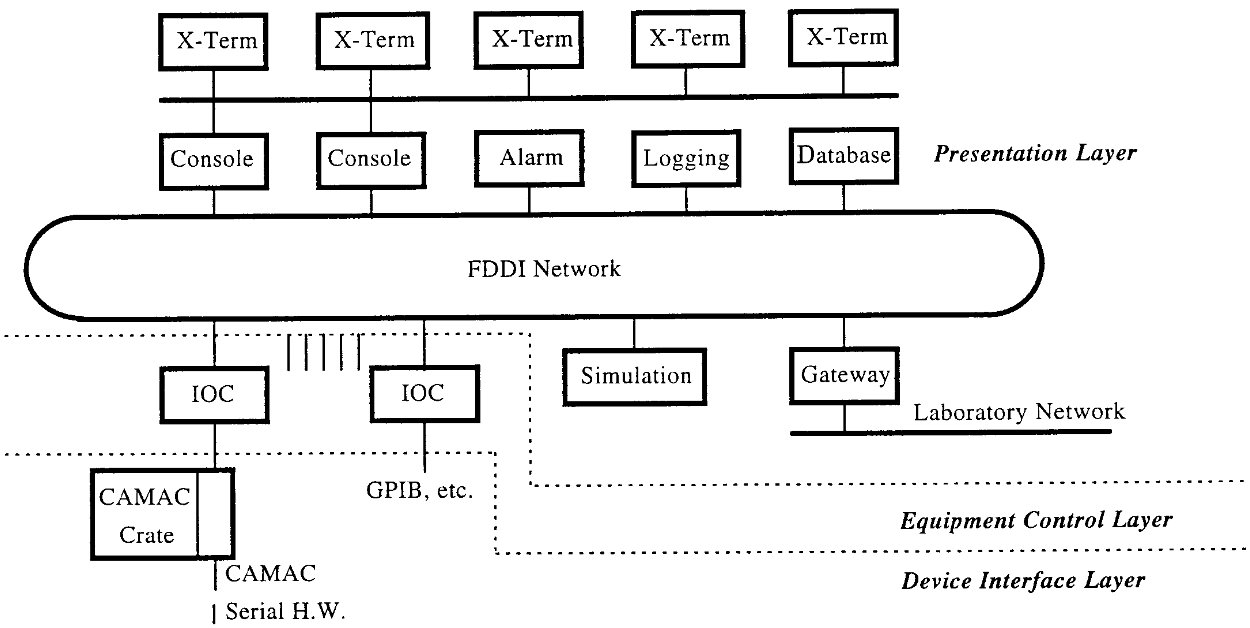

Figure 1. System Architecture of KEKB Control System.

Equipment Control Layer

The equipment control layer consists of IOCs that functionally control the equipment of each hardware group. Each IOC is a VME computer equipped with CAMAC serial highway drivers and other standard field-bus driver modules. The operating system for the equipment control computer is VxWorks. The type of processor on the VME processor board is not yet fixed and can be changed according to the requirements. The minimum requirement is that there must be a cross-development system which runs on a workstation.

Device Interface Layer

There will be several field-buses for the lowest device interface layer. There are CAMAC crates and CAMAC modules which can be re-used from TRISTAN. The CAMAC crates will be connected by CAMAC serial highways or CAMAC branch highways according to requirements. There will also be other standard field bus equipment such as GPIB. VXI modules will be used for the beam position monitors and fast signal measuring systems. There will be about 900 BPMs, and the electronics for them will be in the 20 sub-control rooms around the ring. Where the VXI system is used, it is planned to put a VME processor board into the VXI slot so that it can be used as an IOC. There are about 1900 beam steering magnet power supplies installed in the four power supply rooms around the ring. These power supplies will be controlled through a dedicated bus especially designed for them. A power supply control VME module will transmit parallel control signals and the bus adapters will drive power supply controller modules as shown in Fig. 2.

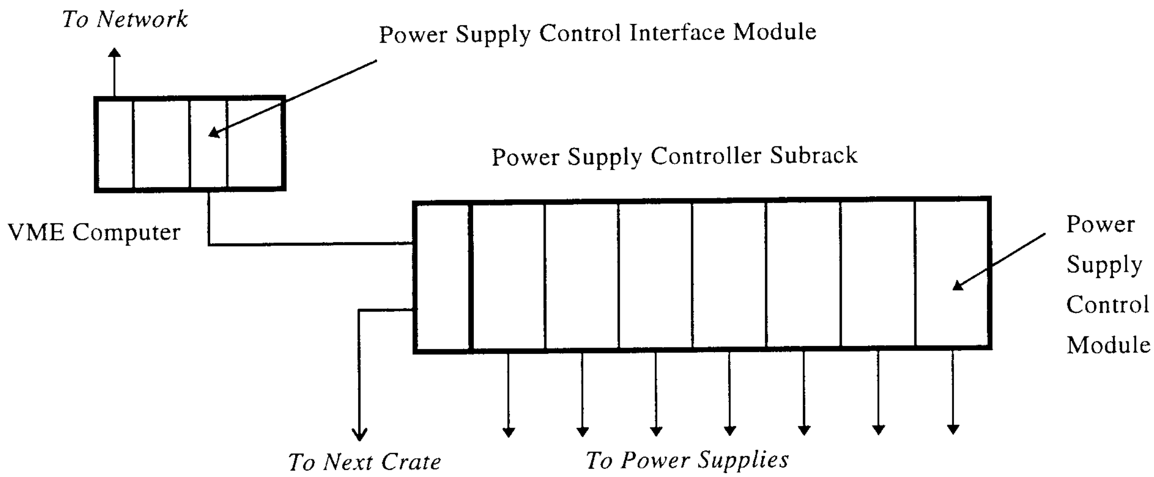

Figure 2. Control Scheme of the Steering Magnet Power Supplies.

CONCLUSION

The KEKB control system is now in the final phase of design and the specifications are being defined. The first system for development will be installed early in 1997; the construction will start at that time and should be finished by the second quarter of 1998. It seems essential to use commercially available products based upon standards and to make use of software sharing to reduce the manpower and effort required. The system should be friendly to the accelerator physicists who create application programs. The database will become the central core of the KEKB control system and will make it possible to combine all the subsystems into one large system.

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