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The rejuvenation of TRISTAN control system

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T. Mimashi, J. Urakawa, S. Kurokawa, .T. Kawamoto, S. Takeda,
A. Akiyama,. K. Kudoh,. K. Komada, T. Naitoh

National Laboratory for High Energy Physics (KEK),
Tsukuba, Ibaraki 305, Japan

abstract

The current TRISTAN accelerator control system uses CAMAC as a front end electronics, and they are controlled by twenty five Hitachi minicomputer HIDIC 80's which are linked with an N-to-N token ring network. After five years from now, these computers must be replaced. This is because of the life time of control system and we have to cope with the requirements imposed by our future project such as the KEK B-Factory and the main ring photon factory projects. The rejuvenation of this control has to be done under some constraints such as the lack of manpower, limited time and financing. First we review the problems of current control system, then the philosophy of the new generation control system is presented. Finally it is discussed how to move to the new generation control system from the current TRISTAN control system.

1.Introduction

Eight years have passed since the current control system started the operation of TRISTAN accelerator [1] [2]. We have a few weeks hardware maintenance for every six month to keep our system highly reliable. The Hitachi company takes care of these maintenance; they clean up each computer, check its operation and replace some parts such as fans, filters, etc. The disk of each computer is replaced every five years. Hitachi also supports 24 hour "on call shift" for any computers troubles. Supported by these maintenances, the current system has been working very stable for these eight years.

Recently some of the I/O devices become out of date, and it becomes difficult to repair these devices. In addition to the problem, the current system can not satisfy the increased requirement of accelerator control. The latter is mainly caused by the lack of CPU power and by the fact that the process computers are all 16-bit machine. And the network transfer capability is limited by the lack of CPU power. In order to solve these problems, it is about a time to start thinking about rejuvenation of TRISTAN control system.

2.The TRISTAN complex and its control system

The accelerator complex of TRISTAN consists of three major accelerators. A 400 m electron linac accelerates electrons and positrons up to 2.5 GeV and injects into the accumulation ring. The accumulation ring accelerates them up to 8 GeV and injects them to the main ring. The main ring is an electron-positron collider . Two electron bunches and two positron bunches are circulating in the opposite direction and collide with each other at the mid-points of four straight sections. The current experiment runs at the center of mass energy of 29 GeV [3].

There are two independent control systems for their operation, one of the system takes care of the operation of linear accelerator and the other takes care of that of the accumulation ring and the main ring. This paper discusses about the rejuvenation of the later system [2].

The TRISTAN accelerator control system uses twenty-five minicomputers and two large general-purpose computers (The main frame: Hitachi HITAC and Fujitsu FACOM) [4].

The minicomputers control hardware equipment and serve for man-machine communication. The general purpose computers are used for the calculation of closed orbit distortion correction which overload the minicomputers. The 25 distributed minicomputers, Hitachi HIDIC 80's, are connected by optical fiber cables to form a 10 Mbps N-to-N token-ring network. From each minicomputer, a CAMAC serial highway is extended to the hardware equipment.

The minicomputers are classified into two groups: the system computers and the device-control computers. The system computers control six operational consoles and two alarm-processing. The device-control computes are three minicomputers for RF cavities control, five for magnets control, two for vacuum controls, two for beam monitor, two for beam transportation, one for timing control, one for program development, one for a gate way between the control system and main frame and one for general purpose.

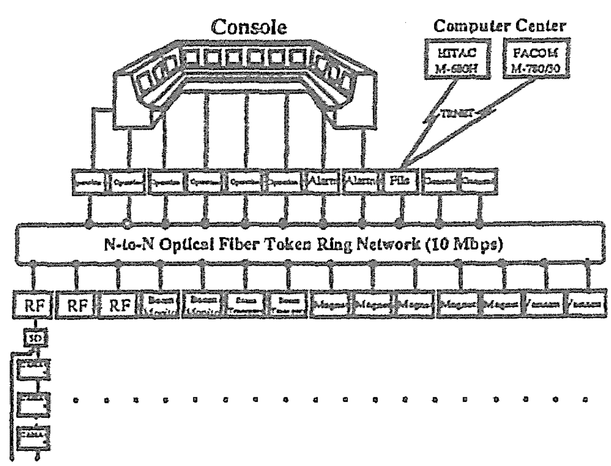

Fig 1: The current TRISTAN accelerator control system

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Accelerators are operated through six identical operator's consoles which consists of two high-resolution color graphic CRT terminals and a pair of touch panels and a VT100 terminal used for a program development.

In the TRISTAN control system, the NODAL system was chosen as an application environment of the system. NODAL, a multi-computer language devised at CERN SPS, has been implemented on HIDIC 80's with enhancements such as a fast execution speed, a dynamic linkage scheme for external subroutines, etc. NODAL has multi-computer commands which enable us to transmit NODAL program from an operational computer to a device-control computer through the network and execute it on the device-control computer. All high level application programs are coded in NODAL and low level subroutines called as the data module are written by the PCL language that is the FORTRAN like language on HIDIC.

3.The plans of rejuvenation of the control system

The basic design of current control system was made by KEK and built by the company in the beginning of 1980's. Since there weren't any good standard products in that time, the proprietary system was built using their own network and process computers. And they developed software tools under their special environment. For example, NODAL is developed using PCL language. This is one of the typical case to build the control system in the industry.

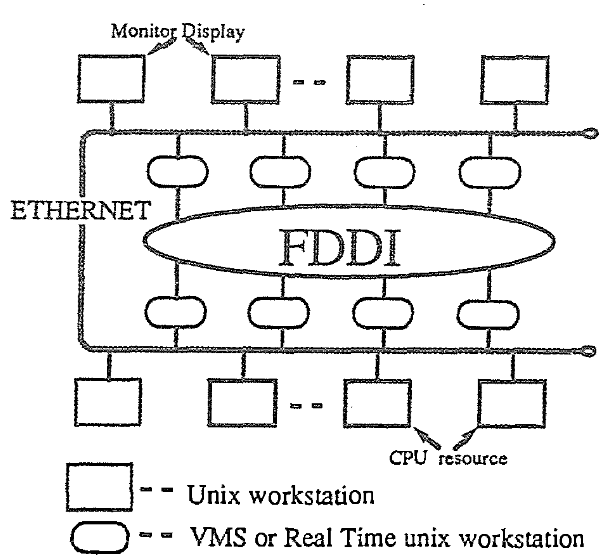

Fig 2 (A) : The possible new control system for TRISTAN using the real time process computers

Some of the industries order the other company to make full control system which includes their special application programs. Once their system was established, there is no change in the application program. People in the industry only takes care of ' Turn Key Operation '. The difference between our control system construction and that of industry is that people in the accelerator department wrote all application programs, and the number of programs has been increased.

Using this kind of relationship to the company, we could build the high quality control system in the short period with small number of staffs. The staff could concentrate on the application program development.

But it results in the single vendor system and the low degree of standardization, for example the system uses special network and special PCL language so that it causes a problem when we try to add the new technology to the system.

The new system should have high reliability, high flexibility, high maintainability, high performance, high extendibility, real time response and at the same time it is important to use multi vendor computers and the standard network protocol. In order to establish this system, the system should be simple and well modularized from the point of view of hardware and software.

The system architecture

The current system consists of two layers. One is the front end layer which is composed of about three thousand of CAMAC modules. And the other is composed of consoles and process computers.

The first step of the system rejuvenation does not touch the front end layer at all, so that only the computing environment will be replaced.

The distributed CPU's and the data base can provide high flexibility and high extendibility.

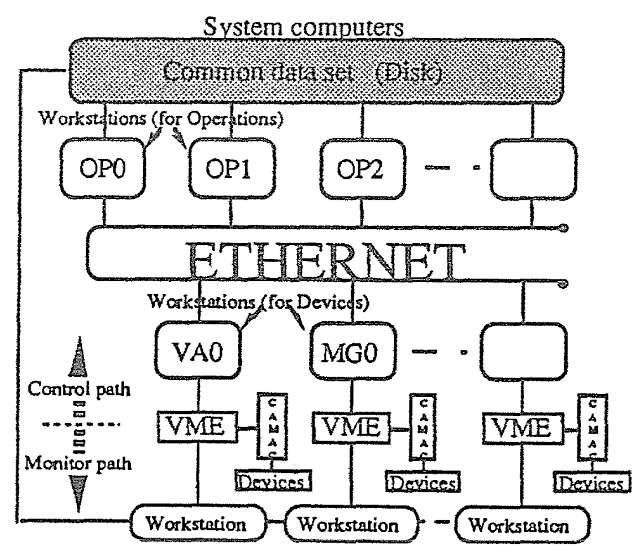

Fig 2 (B) : The possible new control system for TRISTAN using VME modules.

The discussion points are how to link these CPU's and how to handle the real time processes. The system architecture should be simple and the status of each CPU can be seen easily from operator consoles. From the point of this view, the number of hierarchy in the depth direction of the multi-computer system has to be minimized.

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The real time response

In order to get high performance in the reasonable price, Unix workstations and VME modules are good candidates as components of the system. Since a Unix workstation does not have real time response, we have to prepare the real time system using VME modules or special real time process computers that are not well standardized yet. Two examples of the real time system are described in Fig. 2 (A) and Fig. 2 (B). Fig 2 (B) system uses VME modules connected to the Unix workstation to proceed the real time task. All processes that need real time response should be taken care at the VME level, so that the communication between operational consoles and workstations for the hardware equipment control is not necessary to be a token ring which has a real time response.

On the other hand, Fig 2 (A) uses real time Unix or VMS workstations to control real time processes. Since real time Unix and VMS workstations are vendor dependent, the system that deals with real time processes has to be minimized for the future update of the system. And these real time computers must be linked with a token type network such as FDDI.

The software development

The environment of software development is one of the key of successful system. The language should be available in the standard workstation. And programs have to be written easily. NODAL and Object oriented programing are good candidates. We should think about the usage of the commercial software package to save the time.

4.The modularization of the system

When we rejuvenate the control system, the key of the rejuvenation is modularization, because they have to be replaced step by step. In this section, the possible modularization with respect to both the hardware and the software is described.

The modularization of the hardware system

There are some possibilities in the hardware modularization.

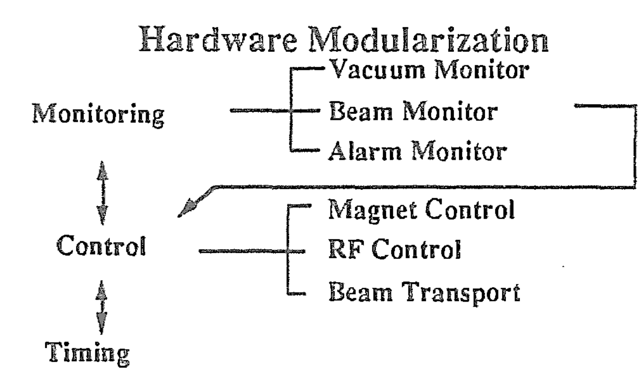

Fig.3 Separation of monitor path and control path

The monitor path can be separated from the path for device control. (Fig 3) The real time response is necessary for only the path of the device control. As same as the current system, the accumulator ring and the main ring can be modularized. It is also possible to modularize the system due to the function of each system, such as vacuum control, RF control, magnet control.

The modularization of the software system

The modularization of software is very important to rejuvenate the system and also important for the object oriented programing. The discussion in this context based on the four levels of control process.

Level 0 : The interface against operator. It must be possible to generalize the action of operators, such as 'select menu', 'input number', 'display data'.

Level 1 : The programs of this level should be written as the words of accelerator operation. For example, 'Measure Closed Orbit Distortion', 'Accelerate the particles','Change tune'.

Level 2 : The programs of this level are discussed as the protocol of the magnet or beam instrumentation operation, etc [5]. The objects of this level are the equipment of an accelerator such as a magnet, a vacuum pump, etc. And there should not depend on the sort of hardware interface, i.e. CAMAC or VME.

Level 3 : For a while, CAMAC has to be used for device control. All CAMAC actions should be defined in this level. When we want to replace some of the CAMAC modules to VME or other hardware modules, the software modification should be done in this level only. The codes should be put in a object library for each hardware individually so that it can be possible to update each hardware control system independently.

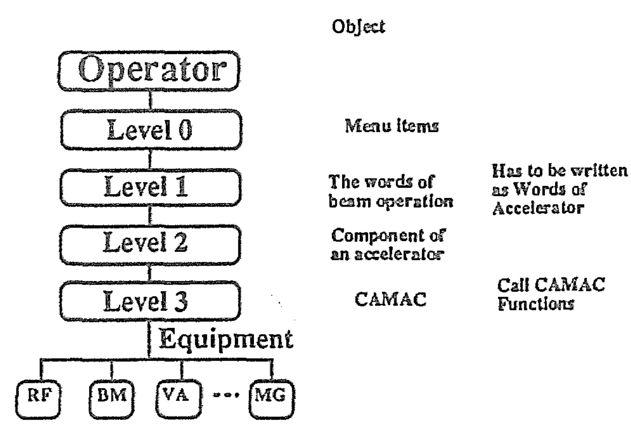

Fig 4 : The software modularization in the object oriented programing for the accelerator control

In each level, the object can be defined easily in the object oriented programing. Since they are well modularized, if CAMAC is replaced by other front end modules, such as VME, the software rejuvenation can be done easily. There must be no effect in level 0 - 2. And

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the part of the programs in level 0 - 2 can be shared in the different accelerators, for example B-factory and the main ring synchrotron radiation project.

5.The transition to the new generation control system

We have just started rejuvenating our control system. Three Unix workstations are installed and we start including them for our accelerator control. One workstation is going to be used to communicate with the linac control system. Since the current control system can not control linac parameters, such as the beam energy, the beam position of the injection line, it will be used to monitor and control some of the linear accelerator parameters and at the same time it sends some informations of TRISTAN ring to their control system. The other workstation will be used to do simulations for an accelerator control. The current control system has used PETROK that is the program for the computation of the closed orbit distortion correction [6]. And recently associating with the implementation of the superconducting Q-magnet, the SAD (Strategic Accelerator Design) which is the set of programs for simulation and optics matching, started to be used very frequently for the TRISTAN accelerator control [7]. The SAD programs are developed for accelerator design in KEK accelerator department. All programs are developed in the main frame: Hitachi HITAC. But the recent drastic improvement of the calculation speed of workstation make it possible to run the simulation in the private workstation. Since the current control system does not support standard network, the project to transfer the data from the current control system to the new installed workstation through CAMAC has just been started.

Because the current process minicomputers are 16 bit machine, the lack of memory causes some troubles.

The graphics has critical problems, so that it will be replaced by the graphics on workstations. In order to remove the current graphic system, the current software codes also must be available in the new workstations until all graphic programs are rewritten. The current graphic system "HIDIC 80-RS232-Graphics controller-CRT" , will be replaced by "HIDIC 80-RS232-Xwindow in the workstation"

The new functions for the accelerator control, such as the real time tune monitor, is going to be constructed with the graphics in the workstations

The possible system in the transition stages

There are several possibilities of the system rejuvenation. One possibility is to install another crate controller into each CAMAC crate so that two independent system can exist until the new system is completed. In any case, the replacement must be done step by step. The biggest change will be network support, unfortunatly at this point, the step by step replacement is impossible. Since the number of programs for man-machine interface are much more than that of hardware control, one possibility is to replace operational consoles with new network system in the early statge, and connect the new system and the old system through the gate way. For a while, both old and new operational consoles must be available. Then hardware process computers can be replaced one by one.

There are several options of this replacement. For example, 1: replace monitoring path such as a vacuum monitoring system, an alarm system first, then replace control path such as a RF control system, a magnet control system.

Actually there have already existed the independent RF control system composed of VAX workstations for taking care of aging of RF cavities. The system can be available for the system replacement.

Another method is 2: replace process computers for accumulator ring operation first, then replace that of main ring operation.

These hardware replacement has to be done together with the software emulations. But the software replacement is more complicated. One of the approach is to try to borrow NODAL program coded in C language from CERN. But even in such a case, all data module subroutines coded in PCL language have to be rewritten in C.

6.Conclusions

The rejuvenation of the TRISTAN control system has been just started to satisfy the increased requirements from complex operation of the accelerator. The Unix workstations and VME's are good candidates as a component of the new system, and some of them have already been added in the current system. The several R&D 's are underdevelopment in both hardware and software. We are going to choose one of the best solutions, but the basic ideas are

1: Use standards and make the open system. 2: Modularize the system and replace them step by step. 3:Use a commercial products to save a time and concentrate on the application program development.

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