A New Approach to Control Systems for Medium-Scale Accelerators

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An accelerator control system which uses an object oriented database has been designed. This control system will be installed in a new accelerator, the STretcher-Booster ring (STB), being constructed at Tohoku University. Furthermore, we plan to change the old control system of the Tohoku University electron linear accelerator to this control system in the next stage. It should become the most suitable control system for medium-scale accelerators on the grounds of both minimized construction cost and good performance.

1. INTRODUCTION

The STB [1] has three operation modes: the first is the stretcher-ring mode, which converts a pulsed beam from a 300 MeV electron linac to a continuous beam; the second is the booster-ring mode, which will accelerate the beam up to 1.2 GeV and inject it into a new storage ring which will be built in a few years time and the third is the storage-ring mode, which will store the beam at 1.2 GeV. The control system has been designed so as to be suitable for these complex operation of the STB. The design goals are to reduce the construction and development costs, to enhance the flexibility and extendibility and to avoid becoming old-fashioned because of the fast innovation of computer technology. In order to achieve these goals, we have decided to employ the latest computer technologies: personal computers and Programmable Logic Controllers (PLC), which are rapidly advancing in performance and object-oriented programming technology.

A simple database system, which saves only the operation parameters, has been used in the linac control system[2]. Since the accelerator will become a larger part of a more complex system, the establishment of a more sophisticated control system is required. A powerful database therefore becomes of great importance. In the future, if this control system is to be adapted to the linac and other accelerators, it should be done without any major modifications. Therefore we cannot afford to develop software that is suitable only for specific accelerators. Using an object-oriented database to enhance the flexibility and extensibility of the control system will provide a good solution to this problem.

2. OBJECT-ORIENTED DATABASE

In general, a database called "object-oriented" should have not only object-oriented programming functions, such as the encapsulation of data and services (methods), a definition of class layers and an inheritance from basic class, but should also have relational database functions, such as a guarantee of data integrity and process checking (rules, triggers and stored procedures). In order to construct an object oriented database having the functions mentioned above together with the ability to respond quickly to query messages, a combination of a Microsoft SQL server and interface programs using Open Database Services (ODS) has been used. The structure of the database is shown in figure 1. The data contained in the database are preset values for normal operation, actual operating values, scanning rates to collect data, PID coefficients for loop controls, alarm messages, bit data from the beam monitors and all other data needed to control the accelerator. These data must be treated by methods constructed from procedures stored in a Structured Query Language (SQL). The stored procedures set the operational parameters for each accelerator device through the PLCs, collect the operational data from the PLCs and store the data to disk. The data and the stored procedures are put together into data tables in the database. One data table is formed together with the data and the stored for each type of device. Common items (voltage, current, coefficients, etc.) in the tables for each category are collected together in tables which are placed in an upper layer. The stored procedures in the lower layers can use the data and stored procedures in the upper layer of the same category corresponding to the inheritance in the object-oriented programming. If a new device is added to the database, the data and stored procedures which should be inserted into the database are only different from that for other devices that have been entered in a few respects, and so it is a form of differential programming.

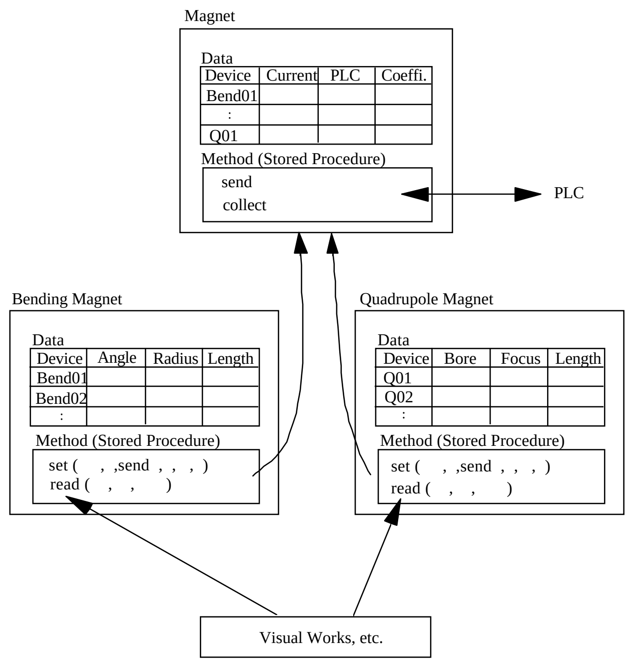

Figure 1: The structure of the database

The distributed-database functions provided by the SQL server will become available further if the accelerator is expanded.

We have completed the basic tests on the database, and have made sure that it will be possible to communicate between the client and the server within several tens of milliseconds.

3. SOFTWARE SYSTEM

Figure 2 shows the software configuration. The control program consists of the object oriented database, based on the SQL server and application programs (Visual Works, Excel, Visual Basic, WWW sever, FINS, etc.) which are commercially available. Visual Works is used as a Graphical User Interface (GUI) on the operator's consoles [3] and provides the SmallTalk language, convenient tools and a number of useful class libraries for program development. Excel is used for the statistical display of logged records. Visual Basic is used as a simple language for sequencing operations. The WWW server provides not only real-time information concerning accelerator operation, but also provides help messages and on-line manuals written in Japanese for the accelerator operators as well as to researchers through the campus network. The Factory Interface Network Service (FINS, supplied by OMRON Co.) is a communication protocol between a personal computer and the PLC. The application programs are connected to the database by means of the Open DataBase Connectivity (ODBC), ODS, or the Dynamic Link Library (DLL). The use of their application programs is of benefit to this control system: there are fewer program bugs than are found in laboratory-designed ones, comprehensive manuals, the expectation of upgrading to new versions in the future, and reductions of the development and maintenance loads. We have adopted Microsoft WindowsNT for the personal computer operating system, because it has various important features: a multi-tasking system taking advantage of 32 bit performance, good network connection and an architecture following the client/server model.

Due to the speed of technical innovations, if much effort is not taken to continuously upgrade the control system, it will become technically obsolete within a few years. To cope with this problem, the personal computers in the system will be replaced by new ones having a higher performance every few years and the application programs will be updated with new versions provided by the software suppliers, or replaced by other similar applications having better functions. Therefore, the control system will be constantly maintained at the optimum condition.

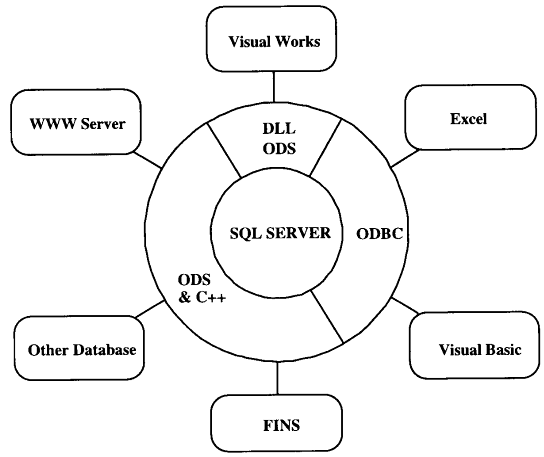

Figure 2: The software configuration

4. PLC

An outline of the control system is shown in figure 3. A PLC has been adopted as a device driver and as an interface between the computer and the accelerator, because the price is lower than that of the CAMAC and VME systems. It is capable of complex control of external devices with simple programs and various modules are available commercially. Recently, because the programming, process speed and network environment of the PLC have improved remarkably, it has become possible to use it for accelerator control [4], except for applications which handle a large quantity of data during a short period

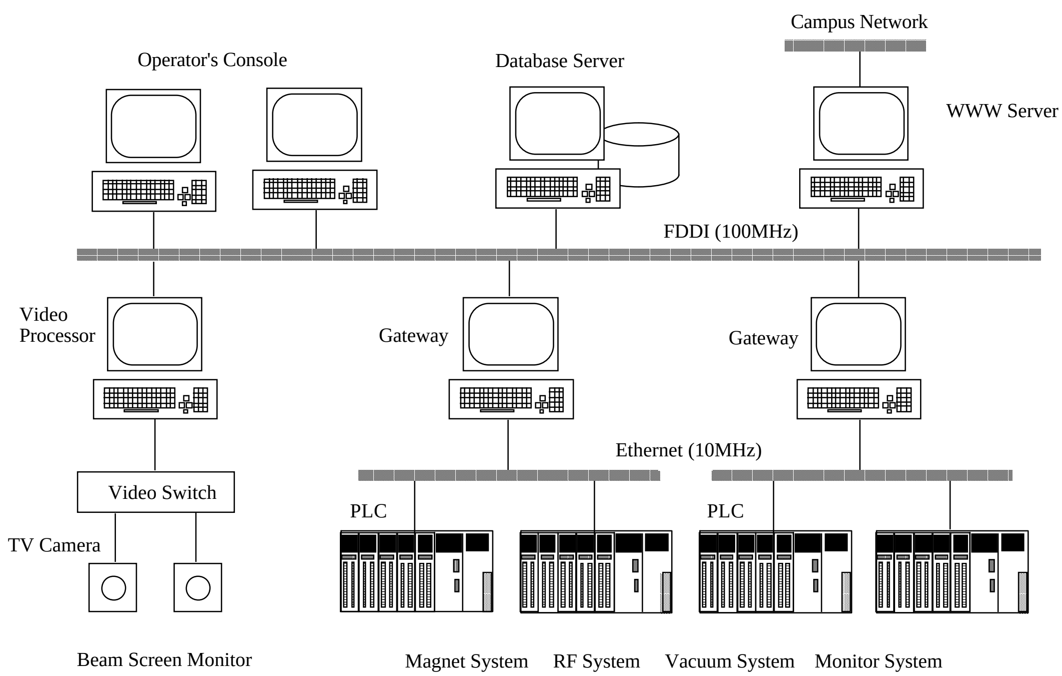

Figure 3: The configuration of the control system

of time.

In this control system, the PLCs will control various magnet systems, an RF system, a vacuum system, a beam-monitoring system, etc. The PLCs function as device drivers that set the operation parameters, monitor the operating condition, check the interlocks (main interlocks are hardwired) and act as a feedback loop controller. The I/O modules used in this system include the following types of module: ADC (12 bit, 8 channel), DAC (12 bit, 4 channel), digital input (16 bit, 4 channel), digital output (16 bit, 4 channel) and GP-IB interface. The program executed in the PLC is developed in a Sequential Function Chart (SFC) running on personal computers connected to the FDDI backbone network and it is stored in the database server computer. When the system starts, the program is loaded into the PLCs with the characteristic data on the controlled devices. The PLCs are connected with a 10 MHz Ethernet using a UDP/IP protocol, and communicate with the database server through gateways (the personal computers) for converting the transfer speeds and protocols.

5. PERSONAL COMPUTER

The performance of the personal computer has improved rapidly during the last few years. Especially in the GUI environment. The appearance of new operating systems available for multi-tasking (OS/2, WindowsNT, etc.), network connection, programming languages and tools for application development, memory and hard-disk capacity and low initial and running cost, makes the personal computer a better choice than the workstation. In our system, personal computers will be used in the following roles: database servers, operator consoles, image processors for digitizing and displaying video signals from beam screen monitors, gateways and WWW servers. All of the personal computers will be IBM PC/AT compatible.

6. CONCLUSIONS

Various basic tests on the database have been carried out and the control system is being constructed at the test facility. Since the STB will start operation for nuclear experiments next autumn, this control system must be completed by next summer at the latest.

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