# Improvements in Database System for Accelerator Control

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**Abstract**

Since the accelerator has become a large and more complex system, the establishment of a more sophisticated control system is required. A powerful database therefore becomes of great importance, and will enhance the flexibility and extendibility of the control system. We have adopted MS-SQL Server as the control database. Although MS-SQL Server is a relational database, in order to enhance the role of the database we encapsulated the data and methods constructed by means of stored procedures. The database must be accessed through the stored procedures to communicate between application programs and the database. Consequently, the communication protocol as an access method between the client applications and the stored procedures could be standardized; it was possible for anyone to make application programs without expertise on the SQL or the database structure. For real-time observations of the accelerator operation through the Internet, a Java Applet using the standardized protocol has been provided. The structures of the database and interface for the application programs are discussed

## 1 Introduction

The STB (STretcher-Booster ring) [1] was completed in October 1997 and has been commissioned. When design of the control system [2] began three years ago, we agreed upon the following basic design concepts: low construction and maintenance costs, installation of an operator-friendly console, realization of easy operation, and establishment of a high level of flexibility and expandability. Because the STB has three operation modes, which include a stretcher-ring, a booster-ring, and a storage-ring, the operation is very complex. Moreover, in the case of the multipurpose accelerator for which both the beam course and beam energy and current are changed frequently, it is generally necessary to provide good reproductions of operation values and statuses of device components in a short period of time. In order to realize these requirements, a database has been adopted as the core of the STB control system. The use of a database has become popular in the recent accelerator control field, but the database primarily plays a role as a simple data storeroom. We have employed the database system as a control manager therefore enhanced the flexibility of the control system.

## 2 Database system

We have adopted an MS-SQL Server as a control database. The MS-SQL Server is a relational database, but it has some additional features: a client/sever model which can be constructed on PCs (Personal computers), ODS (Open Database Services) which can extend the database functions, a relatively low price, as well as compatibility with WindowsNT.

### *2.1 Software scheme of the STB control system*

The block diagram of the control software is shown in Fig. 1. The control system consists of three layers; a human-interface layer as an operator console, a control layer as the database, and a device layer as a device controller. The control database is installed in a WindowsNT Server. Because the database is a control manager, every communication between the operation console and the PLC (Programmable Logical Controller) as a device controller must be executed through the database. The control commands issued by an operator are checked in a stored procedure for the database: for example, a settings for the operation values for each device are less than maximum values and operation commands can be adapted to actual device state diagrams such as for the stop, ready, run and fault states. After checking the commands, related data tables are updated, and control commands are sent to the appropriate PLC through a device manager which establishes the magnet power supply's current or status. The PLC observes the operation of each device every time, and if operation statuses or values are changed, the PLC informs the database of changed conditions, and the values or state diagrams in the database are updated. In order to simulate a beam orbit in the stretcher-ring mode operation and to correct a closed-orbit distortion in the booster-ring mode operation, the simulation and orbit correction programs written in FORTRAN have been provided in the database server computer. These programs also interact with information from the database, and the beam orbits are compensated.

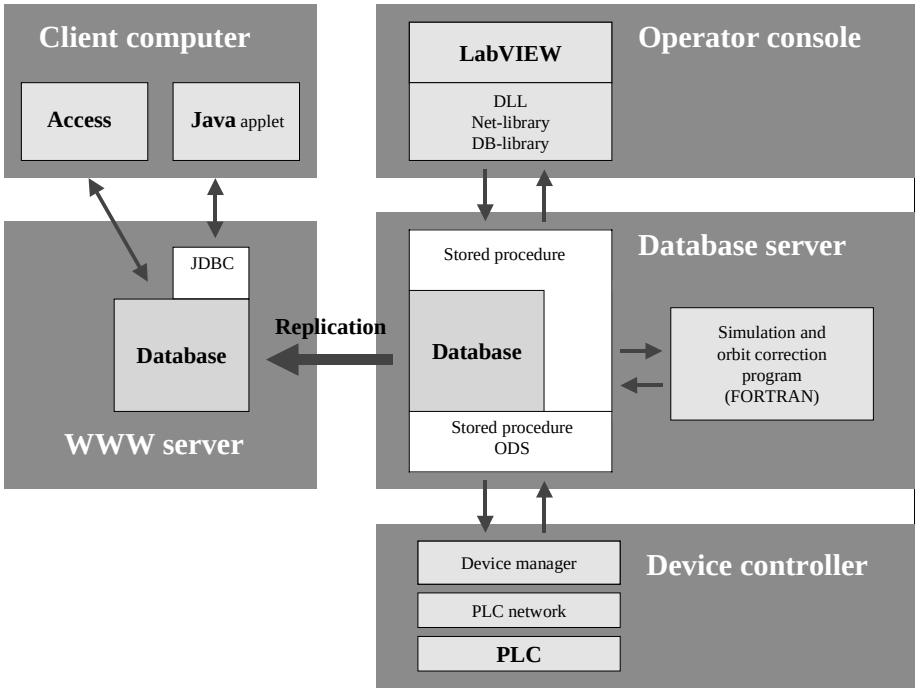


Figure 1: Software scheme of the STB control system.

*2.2 Functional requirements for the database*

Functional requirements for the database system are as follows:
(1) Available for real-time operation at high throughput.
(2) Good connection with application programs.
(3) Provides extendable functions such as the ODS.
(4) Database available for use in a personal computer.

As for item (1), we expect the time from receiving a query to replying from/to client computers to be less than ten milliseconds. For (2), the use of a commercially available software lightens the burden of software developments. In addition, fewer program bugs are found in commercial than in laboratory-designed ones, and they generally come with thorough manuals and regular version-updates. For (3), the ODS is a mechanism which incorporates user programs into the database in order to enhance the stored procedure functions, because the SQL alone can not treat all required control methods.

*2.3 Database structure*

The control database system consists of some databases:
(1) A device property database constructed with maximum output current/voltage, ramp-up rate of the output, coefficient/offset values for setting/displaying , etc.
(2) A device configuration database constructed with module allocation tables in the PLC units, node addresses of the PLC units, specifications of the PLC modules, etc.
(3) A simulation and orbit correction database constructed with geometrical parameters, orbit-calculation parameters, and beam parameters (e.g. twiss parameters).
(4) An operation status database composed of actual operation values such as set and real current/voltage for magnets, vacuum pressures, operation state diagrams, interlock statuses, wave-form data on pulse operation power supplies and pulsed beam, image data from beam screen monitors, etc.
(5) An operation record database constructed from historical operation data, operation and maintenance logs, etc.

Every PLC is forced to run with the same control program, but because each individual PLC must work with different specifications depending on the connected devices, the PLCs then download the necessary configuration tables from the device configuration database.

*2.4 Stored procedure*

If the control data were rewritten by a mistake, much damage would be caused to the control system. The data is encapsulated with stored procedures which behave like a method in object-oriented programming, and is hidden to be protected from improper access. All access to the database must be executed through the stored procedures, and direct access to the database is not allowed except by a few special programs for an administrator. The stored procedures are classified according to the kinds of devices, as shown in Fig. 2. Common control methods in the same category are collected together and put in an upper layer and can be used from lower layers.

It become possible to use the stored procedure as a standardized protocol to communicate between the database system and other programs, such as the operation console, the simulation and orbit correction programs, the device controller, and so on. An example of the protocol is shown in Fig. 3. The message is comprised of the class name, object name, method, property, and values, and it becomes simpler than commands using the SQL. The standardized protocol provides a good environment for the control system because even if people who are not

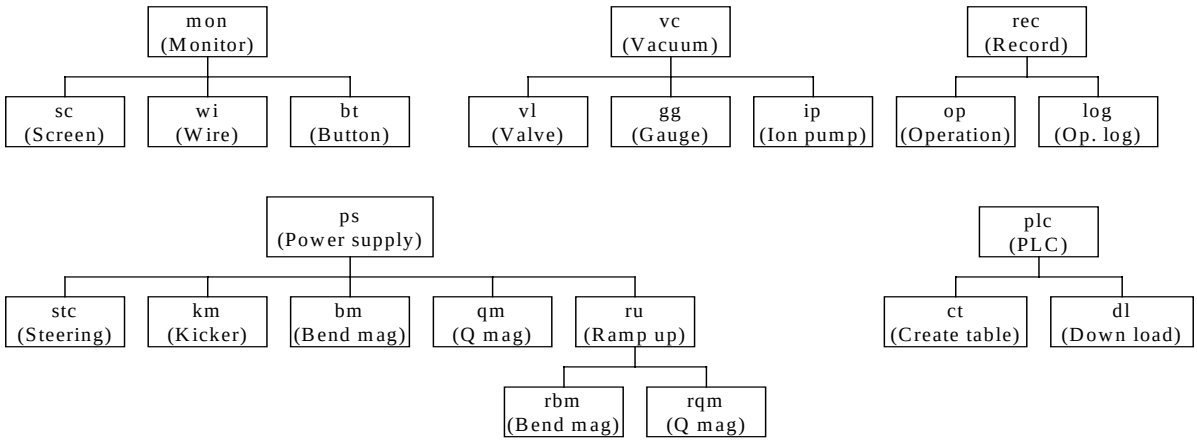


Figure 2: Structure of the stored procedure.

Communication

Class Object, Method [, Property [, Value1 [, Value2, ]]]

**stc ISC01, Set , X_current , ' -2.5 '**

| | |
|---|---|
| Class (Procedure name) | : stc (steering coil) |
| Object (Device name) | : ISC01 |
| Method (Action) | : Set |
| Property or Attribute | : X axis current |
| Value (Current) | : -2.5 (A) |

Figure 3: An example of standardized communication protocol.

acquainted with the SQL or do not know about the structure of database can make application programs in the client computers.

*2.5 Distribution of the database*

As shown in Fig. 1, the database for off-line processing and for servicing real-time information to the Internet is separated from the control database and installed in the WWW server, because the control database must be protected against illegal access from the Internet. Moreover, the separating of the database is advantageous in reducing the CPU load in the server computer for the accelerator control. The transmission of the data from the control database to the WWW database is achieved using a replication function provided by the MS-SQL. The control database is defined as a publication-server, and the WWW database is defined as a subscription-server. The data allowed to be referred to off-line processing and the Internet browser is replicated at intervals of a few minutes.

Vacuum pressures in the STB are being displayed on our laboratory's home [3] page using Java-applet, and we will provide other operation statuses soon.

**3 Conclusion**

The cost and manpower for constructing the STB control system was low because we used a database in the core of the control system, employing commercially available software, and PCs, and PLCs. The database and a standardized protocol have especially enhanced flexibility and extendibility of this control system. We will continue expanding this control system into the Tohoku University electron linear accelerator until late in1998.

**4 Reference**

[1] Oyamada et al., "The Tohoku University Stretcher-booster ring", Proceedings of the 10th symposium on Accelerator Science and technology, Hitachinaka, Japan 1995

[2] Mutoh et al., "A New Approach to Control System for Medium-Scale Accelerators", International Conference on Accelerator and Large Experimental Physics Control system, Chicago 1995

[3] URL:http://www.lns.tohoku.ac.jp/stb/disp2 /display2.html