# Relational Databases for RHIC Design and Control*

C. G. Trahern, C. Saltmarsh, T. Satogata, S. Peggs, W. W. MacKay
T. Clifford, M. Hemmer, E. Scholl, T. Shea, V. Mane
RHIC Project
Brookhaven National Laboratory, P.O. Box 5000
Upton, New York 11973

*Abstract*

The preliminary organization of data via relational databases for the design and control of the Relativistic Heavy Ion Collider (RHIC) is described.

## 1 INTRODUCTION

The RHIC complex of accelerator systems is composed of the existing Booster and AGS rings as ion injectors and new systems such as the AGS to RHIC transfer lines (ATR) and the RHIC collider rings. In the latter cases the opportunity exists to organize the data describing the accelerator complex in an integrated way that will make design, installation, commissioning and operation follow smoothly from one to the other.

This paper discusses databases for ATR and the RHIC collider rings that are being used to design the machines and to provide the information that is necessary for the high level application programs needed for commissioning of the ATR in 1995 and the RHIC sextant test in 1996. Some of the information needed for installation, e.g., fiducial coordinates, is implicit in the physics design of each accelerator, and application programs have been written to generate these derived datasets. In other cases, e.g., the description of how magnets are grouped together by power supply, new structures are needed that can be superimposed on the lattice structure, but may also exist as independent data sets which must be related to specific accelerator components through some key. We will attempt to describe these new data models here.

## 2 DESIGN DATABASES

### 2.1 Lattice Parameters

The lattice design database schema has been in existence since the time of the SSC Central Design Group, and has been used at FNAL, SSCL and BNL to record the design of accelerator systems. This data structure has been described elsewhere[1], and will not be discussed further here. A programmatic interface to this database structure, known as **dbsf**, not only provides ascii input data to most accelerator design codes but also writes a sequential binary description of the design using the Self Describing Standard(SDS)[2] data management system. The lattice dataset in SDS form is key to many of the application programs in use at RHIC, and in particular is used as the basis for the general name lookup table of devices, described in the next subsection. Application programs have been written which transfer SDS data to and from relational database management systems such as SYBASE[3].

### 2.2 Namespace

The Mechanical Engineering (ME), Survey & Alignment (SA), Magnet, Cryogenics, Vacuum, Controls, Beam Instrumentation (BI) and Accelerator Physics (AP) groups each describe devices in the accelerator according to their own purposes, and the names or labels they assign to these devices are not the same. Consequently, the need for cross referencing of names arises immediately. A structure, known as *NameLookup*, has been designed to associate these different names. In its current form this structure is generated programmatically using as input data the lattice SDS description. The program, **slotout**, reads in the RHIC lattice description and constructs a table with the following entries:

| | |
|---|---|
| lattice_index | pointer to lattice design data |
| atom_index | pointer to geometry data |
| fid_index | pointer to fiducial data |
| network_index | pointer to communication data |
| SiteWideName | identifier for ME & Controls |
| SurveyName | identifier for SA data |
| SerialName | identifier from Magnet vendor |
| LatticeName | lattice component design name |
| GenericName | generic component name |

The *lattice_index, atom_index, fid_index* and *network_index* are pointers to derived datasets which reference lattice, geometry, magnet fiducial and communication & controls information, respectively. The so called *SiteWideName* is the unique identifier for purposes of installation and control. The Mechanical Engineering Division uses this name as its primary reference to components in their layout drawings of the ATR and collider rings. The integrity of these drawings is a key aspect of the installation procedures, and the coupling of the lattice design via *lattice_index* & *LatticeName* to these drawings is provided by the use of their common reference in *NameLookup*.

### 2.3 Survey & Fiducial

The SA group at RHIC has resposibility for the fiducialization of installed components. Measurements both outside and in the ring are made and stored using a database

*Work supported under the auspices of the U. S. Department of Energy

schema previously discussed by M. Hemmer[4]. The *SurveyName* is the primary key in the survey database. It is a name attached to the tunnel location of fiducial bearing components. Accelerator Physics communicates the location of fiducials to SA via algorithms based on their correspondence to this name in *NameLookup*. A C program running on a portable PC will be used in the tunnel during alignment measurements. This program uses AP's computation of the fiducials as determined from the lattice design in conjunction with any errors measured by SA to determine new fiducial targets online. The actual measurements of these same fiducials will then be stored and compared with predictions after first loading the measurements back into the database management system.

## 2.4 Magnet

The BNL Magnet division is responsible for the construction and testing of all superconducting magnets for RHIC. Magnet identification is assigned at the vendor's manufacturing facility, and this *SerialName* is the primary key used throughout the Magnet division information system. At the time of installation, a specific *SerialName* will be associated with a *SiteWideName* in *NameLookup*. This association will establish the linkage of most sources of information about this magnet.

A database schema for all test data which includes multipole and intrinsic fiducial measurements amongst others has been developed[5] in a PC based Foxpro[6] system. This data will be transferred to the general SYBASE server for use in magnet sorting algorithms by RHIC AP as well as for archival purposes.

During the installation of magnets, the RHIC AP group will decide on the basis of the above data whether to place a given magnet in a specific location to compensate for possible systematic errors present in other magnets nearby. A schema has been developed to construct a history of this selection process from the time that a magnet enters BNL to the time of installation. Magnets will be judged on the basis of their multipole moments and tagged appropriately in these tables by AP. Instructions to the installation manager will be based on the analyses stored in these tables.

## 2.5 Aperture & Impedance

RHIC AP requires a description of the aperture and impedance values throughout the accelerator. Since the segmentation of a given slot space in the machine by aperture or impedance need not correspond to its segmentation in terms of magnetic field values as recorded in the lattice design, we have associated a new name, *GenericName*, with each slot in the lattice to provide this additional information. A series of tables have been designed which uses *GenericName* as a key to the segmentation of the lattice components for aperture and impedance. *NameLookup* again provides the cross reference via *GenericName* to other data stores.

A visualization program that will construct a 2-d picture of the aperture as a function of longitudinal position along the beam is planned. This program will combine data from the lattice design, *NameLookup* and aperture tables to create a futher dataset which can be plotted easily. The impedance geometry information recorded in the above tables will be downloaded via a similar program to codes such as **MAFIA**[7] for computation of actual impedance values. The computed impedance values will then be reloaded to the DBMS as a named list for further analyses.

## 2.6 Controls & Generic Device Descriptions

The overall plan for RHIC controls has not yet been completed. However, various aspects of the design of the control system have been agreed upon, and the description of the data structures for these "parts" has begun. One database is being developed for inventory of control hardware, and another begins to address software configuration issues for the Accelerator Device Object (ADO) classes[8] that will underly most application programs. The former is needed for managment and maintenance of the equipment being used in the control system and the latter as a static source of configuration data for ADO parameters, categories, and properties.

The Accelerator Device Object is an abstraction in software of a physical device. The ADO description contains both parameters and methods; the methods allowing the ADO to respond to actions directed at it by other processes in the control system. Parameters include possible settings or readings associated with a device, and these parameters are grouped into categories. Categories of parameters include *Setting, Measurement, Configuration data, Usage data* and *Diagnostic data.* Parameters also are specified by additional properties such as the setting value, high and low limits for the setting, etc. Each *category* of parameter has the same group of parameter *properties.* The ADO configuration database is the source for all of the above data for each ADO.

In addition to these databases, high level control applications such as beam threading and ramping have been addressed as case studies of how complex systems of ADO's will be managed. As understanding of these processes improves, the need for additional data structures to support the applications arises, and this has led in several directions. For example, to control magnets on a given power supply, one must detail the connections of a given device to its immediate hardware environment (front end cabling) as well as construct the list of all such magnets on a given supply (ganging). The cabling issue is an immediate problem for installation and testing, and the ganging issue is a problem for commissioning hardware and software.

We have developed a database description of all these connections in a set of tables called *Generic Device Description* or *GDD.* The details of the *GDD* database design are discussed by Satogata[9], and an entity relationship view of the schema as rendered by the program **Erdraw**[10] is shown in figure 1.

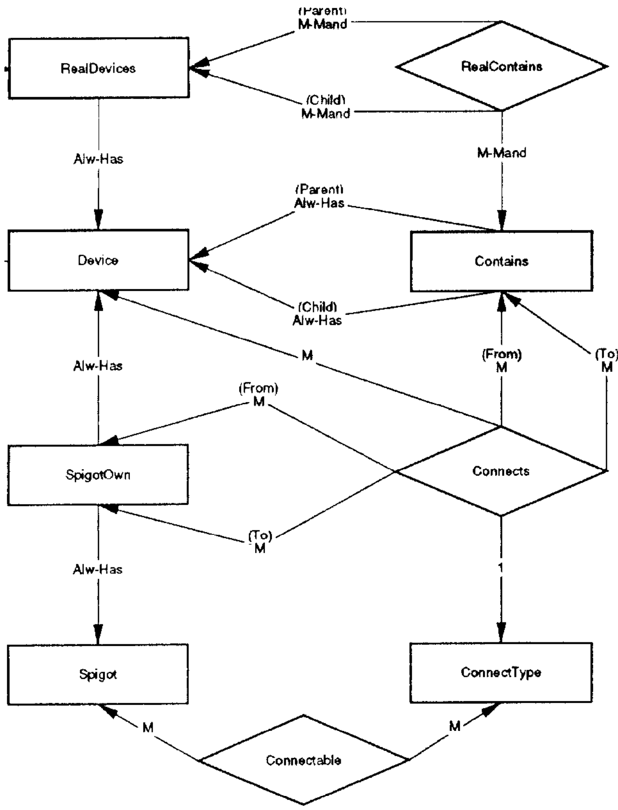


Fig. 1 Database schema of *GDD* database.

The structure of these tables is sufficiently general that disparate problems such as cabling of beam position monitors and other hardware devices, power supply ganging, and waveform generator configurations for power supply ramping can be resolved within the same structure.

### Beam Position Monitor Cabling

The routing of both long cables, connecting the physical BPM to its electronic's niche, and short cables, connecting the BPM signal to the front end processors, has been specified in the *GDD* tables. An interesting use of this data is to create cable and signal wire names to be used as labels. A general algorithm is specified for a naming convention, and a program is written that accesses *NameLookup* for BPM entries, and *GDD* for information about BPM connections. The data thus generated is loaded into tables which contain other relevant data such as cable length, manufacturer, etc.

### Power Supply Ganging & Ramping

The ganging of magnets by power supply is treated with the same structure, but the connections between power supplies and magnets are not in a 1-1 relationship as in the cabling scheme above. Although the power supply configuration of the main arc dipoles and quadrupoles of RHIC is a serial list, the configuration for the interaction regions is more complex as many power supply busses may feed through a given magnet. A picture of an IR power supply configuration is shown in figure 2.

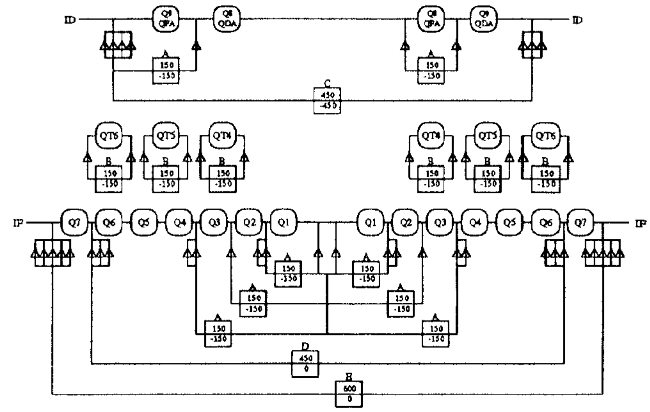

Fig. 2 Power supply configuration for IR quadrupoles. Waveforms[11] to control the ramping of power supplies for this region are generated with this set of connections as one of the input sources for the computations.

## 3 CONCLUSIONS

Relational databases are aiding in the coordination of the data needed to construct and operate RHIC. A plan that details the global data flows and stores needed for the RHIC control system is under development. Relational databases will play a major role in important aspects of the RHIC installation effort.

## 4 REFERENCES


[1] S. Peggs et. al., SSC-N-606, March, 1989; S. Peggs et. al., in IEEE Particle Acclerator Conference, San Francisco, USA, May 1991, pp. 207- 209; C.G. Trahern and J. Zhou, in ICALEPCS proceedings, Tsukuba, Japan, November 1991, pp. 538- 541.

[2] C. Saltmarsh, "ISTK Overview and the SDS Document", RHIC AP note #29, June 1994.

[3] SYBASE, Inc., 6475 Christie Avenue, Emeryville, CA, 94608.

[4] F.M. Hemmer, "RHIC Electronic Data Collection and Survey Data Base", in Proceedings of the Third International Workshop On Accelerator Alignment, Annecy, France, October 1993.

[5] D. Mcchesney, private communication.

[6] Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399.

[7] T. Weiland, Particle Accelerators 15 (1984), pp. 245-292.

[8] T. Clifford, "The Console Level Computer Program Interface to Accelerator Device Objects", RHIC Controls note, October 1993.

[9] T. Satogata, RHIC AP note # 33, July 1994.

[10] V.M. Markowitz and A. Shoshani, "An Overview of the Lawrence Berkeley Laboratory Extended Entity-Relationship Database Tools", LBL Technical Report LBL-34932, 1993.

[11] J. Kewisch et. al., these proceedings.