ISBN: 978-3-95450-194-6 ISSN: 2226-0366 doi:10.18429/JACoW-LINAC2018-TUPO130

THE DESIGN OF HEPS MAGNET DATABASE AND APPLICATIONS

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Abstract

HEPS (High Energy Photon Source) is a planned ultra-bright and extremely low emittance synchrotron light source which will contain about 2500 magnets. The magnet related data including design, measurements, tests, and operation are typically scattered in various storages which can be hard to access for high-level purposes. For such a large number of magnets, it is very important to have essential magnet information systematically stored in relational databases for efficient management and applications. This paper outlines the conceptual and the functional design for the HEPS magnet database and its associated applications, mainly for design of the database schema and application software architecture. This database is developed with MySQL. To provide a better view and access function of magnet related data, a web-based management platform has been developed for data uploading, querying and data managing.

REQUIREMENTS ANALYSIS

Magnets are among the most important components for a charged particle accelerator. From physics and engineering design to online operation, many kinds of information will be generated. The HEPS magnet related data workflow is shown in Fig. 1. We would like to capture and store all essential data regarding a magnet. For the moment, the Magnet Database is focused on related needs of magnet data management, which includes support for a few particular magnet measurement methods. It should be easy to add more measurement method support at any time. Applications for this database will provide magnet operation curves for the control system [1].

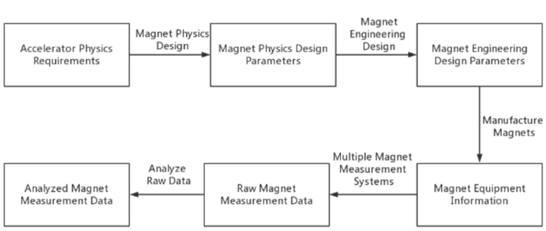

Figure 1: Magnet related data workflow.

Besides the magnet database mentioned here, it is also necessary to establish links for other related data. As magnets being installed and becoming part of the accelerator, the magnet operation data will then be collected and related to this magnet database. Again, the link between the Magnet Database and operation database is through the manufacture equipment ID tag.

DATABASE DESIGN

There are many magnets related data for an accelerator and various applications need to access a combination of these data. With an overall consideration, it is better to store such complicated data in a well-organized relational database like MySQL.

Conceptual Structure Design

The database schema design is implemented to MySQL database systems via MySQL Workbench. The schema holds the following data: magnet design data, magnet measurement data, magnet excitation curve data, and magnet operation or beam-based measurement data in the future. The complete database design schema generated by MySQL Workbench is shown in Fig. 2.

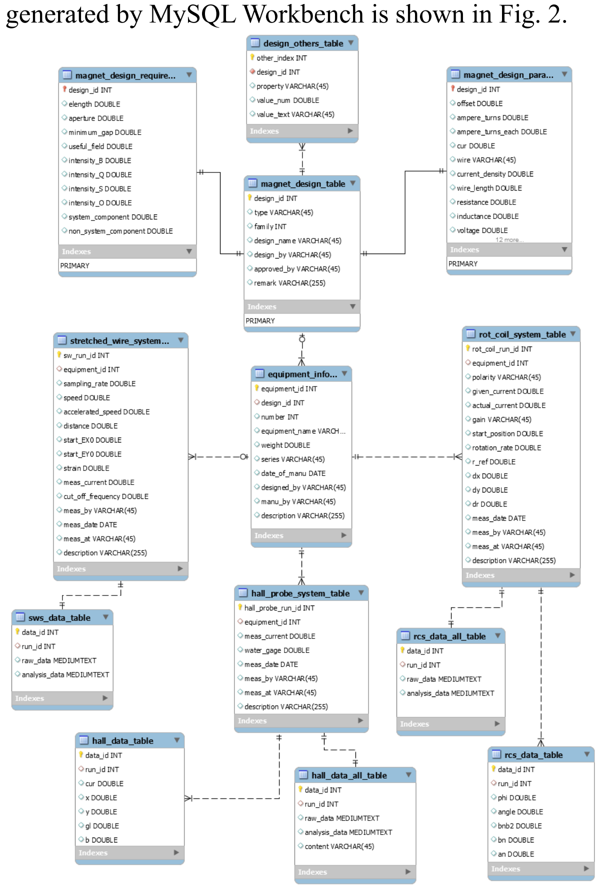

Figure 2: Magnet database schema.

Logical Structure Design

From conceptual design to the logical database design is an important part of the design process. EER (Enhanced entity–relationship) model concept design phase was to reflect the needs of the magnet data model, regardless of the specific DBMS. In order to establish the

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required database, conceptual models need to be converted to a specific DBMS support data model. Logical design results based on MySQL are shown in next three sections, including the description of each table and its main fields.

Magnet Design Data

The magnet design section includes the following tables:

- Physics design requirements table
- Engineering design parameters table
- Basic design information table
- User defined parameter table

All the basic parameters such as type and family are stored in design information table, so they can be easily related to other tables and data. The physics design requirement table and engineering design parameter table hold specific magnet design parameters and drawings. The user-defined table was designed to allow different kinds of magnet design with various and flexible parameters. We choose the property name-value pair so the table is general enough for handling most design parameter types.

Magnet Equipment Information Data

The magnet equipment information table is the centre of the whole schema. It connects the data generated before and after the magnet is manufactured by the equipment ID parameter. The table includes the basic information of actual magnets, such as equipment name, weight and series number. Magnet operation data will be stored in Physics database in the future which may provide analysis such as Beam-based Alignment (BBA) results and connect with device information table to add magnet installation and runtime data.

Magnet Measurement Data

The magnet design section contains three measurement systems:

- Stretched wire system
- Rotating coil system
- Hall probe system

All these systems include a measuring condition table and several measured data tables. The measuring condition table stores specific parameters of each system along with the measured date, site performed the measurement and testers' names. Measurement raw data are stored in text format which can be easily exported. For rotating coil and hall probe systems, some formatted raw data can be extracted from the original data files in Excel into MySQL tables and become easier to access and analyse. Users can upload these Excel files through a web-based management platform for now and this function can be plugged into magnet measuring system to upload and extract automatically. Measurement analysis data can be in many different file types, so it is uploaded and saved in the database rather than extracting numbers into MySQL tables. For better query efficiency, the file is saved to a local server machine and the path to the file is stored in the database.

MAGNET MANAGEMENT PLATFORM

The magnet management platform is responsible for providing data upload, access, and display functions through a web browser. People in charge of the magnet design, device registration and measurement can upload the related information separately. All these data sections can be retrieved by several query conditions. Since the tables in MySQL are linked with each other by primary keys and foreign keys, the related data is easily accessible when query specific data.

Key Technologies

The web-based management system provides several data upload and query pages. One can upload magnet data by filling in a simple form or query the wanted information by selecting query conditions.

Data persistence is managed by the Java Persistence API (JPA) which is a standard API for accessing databases from within Java applications [2]. The main advantage of JPA over JDBC (the base Java API for interacting with databases) is that in JPA data is represented by classes and objects rather than by tables and records as in JDBC. Using plain old Java objects (POJO) to represent persistent data can significantly simplify database programming. In this project, every magnet table is represented by an entity object and all the entity objects are stored in MySQL database. Several popular JPA implementations are Hibernate, TopLink, EclipseLink and Open JPA. These implementations are Object Relational Mapping (ORM) tools. The mapping bridges between the data representation in the relational databases (as tables and records) and the representation in the Java applications (as classes and objects). Compared with other ORM tools, EclipseLink is more standard compliant, since it is the reference implementation for JPA 2. Therefore, it is chosen for the implementation of the JPA.

The MVC pattern is applied to the web-based query platform [3], as shown in Fig. 3.

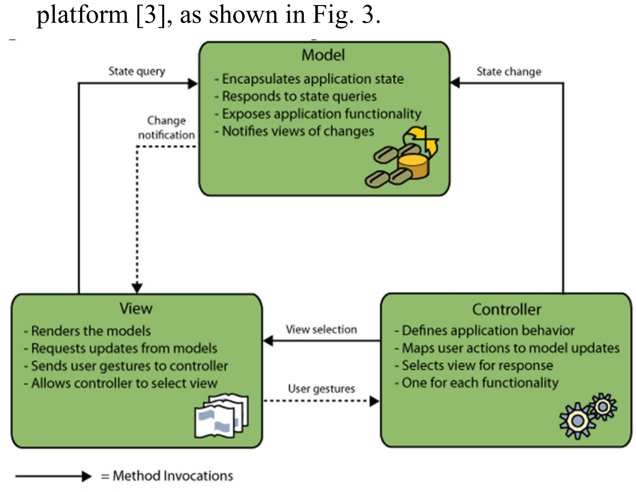

Figure 3: MVC pattern.

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Data Upload

Figure 4 is the design data upload page. Since the magnet design types are limited, all of the magnet design data is required to upload from the uploading form. The form can be divided into four parts: physics design, engineering design, other information and design drawing.

To keep the magnet data uniform, every set of input data is restricted to its own type and format according to its parameters. Users can also add new magnet types, families, and parameters through the GUI buttons.

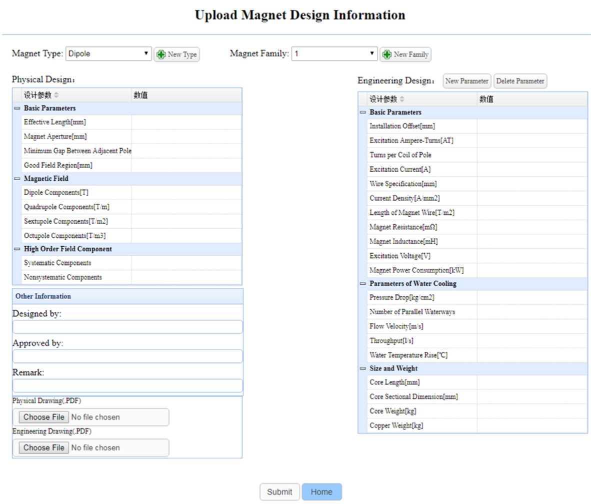

Figure 4: Magnet design upload page.

Every magnet device is linked to one uploaded design, so when uploading the magnet device information, users need to search the design data and select the right design type. Because of the big number of magnets, the magnet device data can be load by batch, and users can upload multiple pieces of device information at one time.

Magnet measurement information page requires users to select the tested device at the very beginning, and then fill in some basic measurement conditions as well as select a raw data file and multiple analysed files to upload.

Data Query

Since the design data, device data and measurement data are all linked by equipment ID tag, users can get all the related data when querying a specific magnet. When queried device information is retrieved, users can simply click the “get the design information” link to open the design data table and get the detail information. The “get the measurement information” button is used to redirect to the measurement data page. After choosing a measurement type, all the measurement conditions will be listed. Clicking the “check measurement files”, a file list will then pop out for users to download all the files.

The design information and measurement data can also be queried independently with multiple search terms, such as magnet type, magnet family or magnet intensity.

SUMMARY AND OUTLOOK

The magnet database and its web-based management platform can satisfy the functional needs of users and the data can be processed steadily through the system analysis, system design and system development stages. Through understanding of magnet data and related device operation flow, we put forward some ideas and prospects for future development and software system upgrading:

- Connecting with beamline and naming databases to record the online magnet information and process variables in EPICS (Experimental Physics and Industrial Control System).
- Adding the upload model of the magnet measure system and implement the automatic magnet measurement data upload function.
- By using the Machine Learning Platform [1], the online status and service life of magnet equipment can be monitored and predicted.

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