EqDb — EQUIPMENT DATABASE FOR COMPLEX EXPERIMENTS*

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The Equipment Database (EqDb) is an information system, which is intended to support construction, assembly, and operation of complex equipment for any physical experiment, *e.g.* for detectors in high energy physics experiments.

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1. Introduction

The idea of the Equipment Database (EqDb) derives from ALICE Detector Construction Database (DCDB) [1], which was created for ALICE experiment at CERN [2]. Comparing to DCDB, goals of the EqDb are considerably wider, and its data structures and applications are completely redesigned.

The EqDb system is originally intended to be used for construction and operation of MPD (MultiPurpose Detector) [3] of Nuclotron-based Ion Collider fAcility (NICA) [4] at Joint Institute for Nuclear Research (Dubna, Russia). Thanks to its generic, highly flexible structure, the EqDb system can, however, be quite easily configured to support almost every type of complex experiment.

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2. Main tasks of the Equipment Database

The main tasks of the Equipment Database (EqDb) is a support for construction of the experiment equipment: support for equipment assembly, tracking assembly of components and parts utilization, support for cabling, storage for component measurements results, *etc.*

The EqDb system supports also equipment construction logistics, including parts ordering, inventory of parts and components, and directory of involved persons and institutions, with possibility to relate a person/institution to equipment components and processes.

Support for operation of the equipment can also be provided by the system, including tracking equipment modifications, monitoring cabling changes, storage for component tests results, *etc.* Thanks to its flexible structure and open interfaces, the EqDb can also be used as a calibration database for the experiment.

3. EqDb technical concept

The EqDb system is designed as data-based information system, developed on top of typical relational database, but conceptually object-oriented and generic — metadata driven.

3.1. EqDb data structures — an overview

Each entity stored in the database is an Object, as shown in figure 1. Several classes — children of Object supertype — are designed, and each of them can have further subclasses, *e.g.* Institution class can have subclasses like Manufacturer and Laboratory, *etc.*

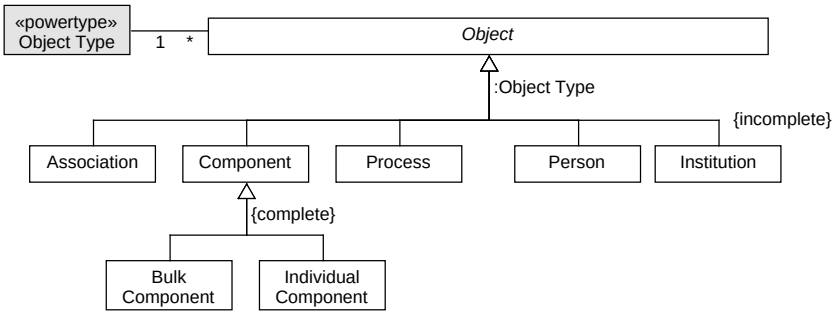

Fig. 1. EqDb objects structure: powertype, supertype and subtypes.

The inheritance is controlled by Object Type class, which is a powertype, *i.e.* a metaclass, whose instances are subclasses of an Object class. So both Manufacturer and Laboratory subclasses are equivalent to Object Type instances.

The most important class shown in figure 1 is the Component class, which models parts and more complex components of the equipment. It has two subtypes: Individual Component models these components, which should be individually identified, and Bulk Component models these parts, which are indistinguishable, and we need only information of their sort/brand and quantity, *e.g.* screws or nuts.

Some typical classes such as Person and Institution are designed to store typical data. Process class models processes, which can be executed on parts or components, such as purchase, assembly, disassembly, *etc.* These typical classes can be further specialized using the powertype, as mentioned above. The list of these classes is not closed, new ones may be added if necessary.

Figure 2 shows properties structure. The structure is generic — metadata driven (metadata items are marked with gray background), so new subclasses — object types can be easily defined by data administrators and new properties can be defined and assigned to object types, without need to change the database structure.

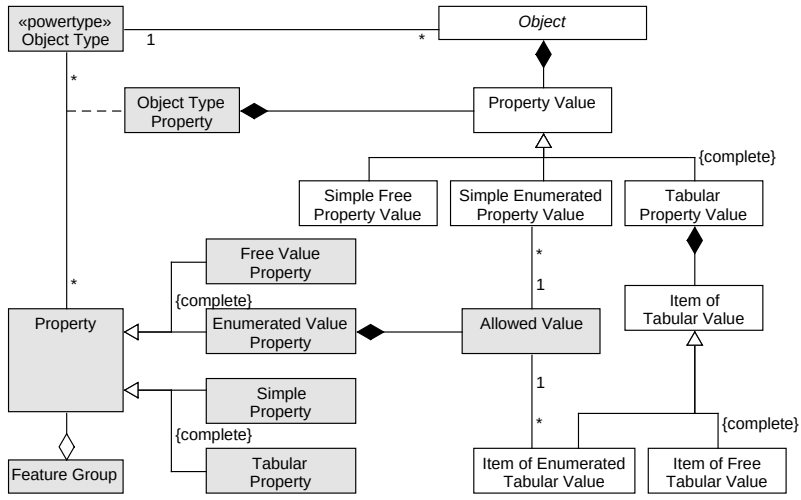

Fig. 2. Properties of objects in EqDb generic structures.

Properties class defines properties of objects. For each subclass, defined as an instance of the Object Type powertype, appropriate properties are assigned. Object Type Property class models the details of this assignment. For each object the property is assigned to, a property value is stored, as modeled by Property Value class.

Properties can be defined as having free values — entered as text, with restrictions based only on defined property data type (*e.g.* a date must have an appropriate format). They can be also defined as enumerated values: a value must be chosen from the list of allowable values, as defined by Allowed Value class.

Properties can also have tabular form: a value of the property is an ordered table of free or enumerated values.

Properties (and associations) are categorized by Feature Group class, which makes it easier to find an appropriate one.

Association class (see figure 3) models associations between objects of any class. Being itself a child of Object, Association class can be specialized into subclasses, having their own properties and "nested" associations. For example, a cable connection can be modeled as an instance of Connection subclass of Association, which, in turn, has associations with three components: a wire and two connectors.

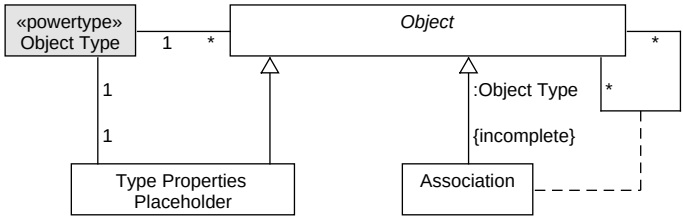

Fig. 3. EqDb associations and type properties.

Special Type Properties Placeholder class, shown in figure 3, enables storing so-called class properties, *i.e.* properties (and associations) of a class rather than its instances. For example, if we create a subclass of Component to model some type of device, we may want to store some parameters describing this type as a whole, not a particular item.

Part of EqDb data, *e.g.* values of the properties, can be versioned. All metadata changes can be logged.

3.2. EqDb technology

Though conceptually object-oriented, the Equipment Database is implemented using standard, proven and efficient relational technology.

The EqDb database is built in Oracle RDBMS (version 11 rel. 2 or newer is needed). The EqDb system can be installed on any Oracle RDBMS edition, from free Express Edition, up to Enterprise Edition, when it can take advantage of support for VLDB, given by Oracle Partitioning Option. The system is highly scalable: the database can easily be ported from less to more powerful Oracle edition as the data grows.

EqDb applications are built with use of Oracle Application Express — simple yet powerful tool to create Oracle-based Web applications.

As the utilized technology is widely used and delivered by the company having very high market share, the technology is safe from both technical and business points of view. It is expected that the EqDb information system can be maintained and supported for a long time.

4. EqDb applications

The EqDb contains several applications for end-users and administrators.

The EqDb Metadata Wizard is an application for data administrators, which can be used to define generic — user-definable part of the Equipment Database data structure, *i.e.* object types, generic properties, associations, *etc.* (see figure 4).

The EqDb Data Editor is the main EqDb application for end-users, used to search and edit the data, and to view some typical reports on the data.

Additional specialized applications can be created for particular groups of users, who have special needs, *e.g.* related to cabling, automated inserting of measurements results, *etc.*

All the modules are developed as Web applications, which can be used with any standard Web browser.

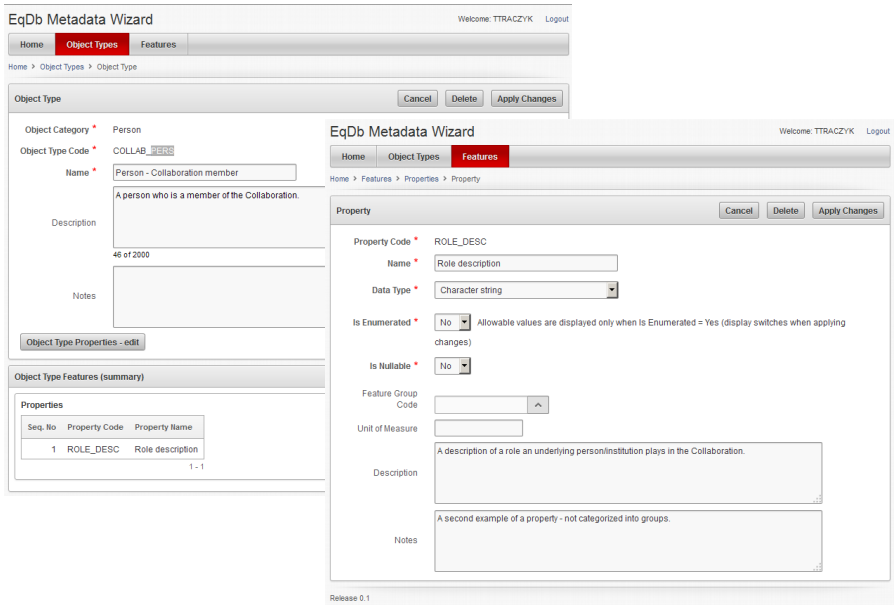

Fig. 4. Exemplary EqDb Metadata Wizard screenshots.

4.1. EqDb support for cabling

Cabling management is a crucial problem of contemporary infrastructure, and it is especially important and difficult in the case of complex physical experiments, as the number of used cable connections is enormous, and the connections need to be modified as long as the experiment evolves.

A specialized EqDb subsystem, called Cabling Management Module, is currently under development. The subsystem will provide possibility to define cabling connections (as mentioned in Section 3.1) and to monitor them in real appliances.

At MPD detector, a hardware solution is used for monitoring of cable connections. It is based on R&M technology called R&M Intelli Phy [5]. The technology uses RFID clips to mark cable ends, and special sensorbars, mounted in standard equipment cabinets. The sensorbars contactlessly read current positions of cable connectors, and report them via standard copper or fiber-optic network to the monitoring software.

The EqDb system will read the data stored by Intelli Phy monitoring software, and will compare it with connection definitions in the EqDb database, enabling user to easily track any changes or mistakes, and to synchronize the EqDb database with the actual connections state.

5. Conclusion

The novel Equipment Database (EqDb) system is designed to support construction, maintenance and operation of any complex experimental equipment. Particularly suited to needs of high energy physics experiments, the system can be used on every stage of the experiment: from construction logistics, up to calibration of appliances and cabling monitoring.

Design, based on industry-standard software and proven solutions, ensures stability and longevity of the system.

Thanks to its flexible generic data structure, the EqDb system can be quite easily adapted to needs of almost any equipment of complex physical experiments.

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