WEAP068

PRODUCTION PHASE DATABASE FOR STAR SILICON STRIP DETECTOR

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Abstract

The silicon strip detector (SSD) of STAR is a large silicon detector reaching almost half a million channels and made of thousands of components. In order to help in the long production process and store detailed information of the state of the detector a database system has been set up that contains the main characteristics of all the elements of the SSD. This system includes procedures to enter data from production test benches, to consult, modify and analyse these results as well as to sort or set qualities for tested objects. It is based on a well known database system and usual tools for the WWW interface. We describe here the the architecture of this system, its main features and possibilities and some applications.

1 INTRODUCTION

The silicon strip detector (SSD) [1] is an upgrade of the current STAR experiment setup, adding a fourth layer to the Silicon Vertex Tracker (SVT). It consists of double sided silicon sensors over a surface of around one square meter. To match the high track densities reached at RHIC with Au+Au collisions at $\sqrt{S_{NN}} = 200$ GeV the granularities of the strips is such that the total number of channels reaches 491520.

The detector itself is a barrel of 320 detection modules, each of them made of one silicon sensor (or wafer), twelve readout integrated circuits ALICE 128c, two hybrids that support the readout circuits, and two COSTAR integrated circuits dedicated to the slow control of the detector. The barrel is built out of twenty carbon ladders, each one supporting sixteen modules. To be able to read all the channels in a relatively short time, (below 5 ms), the readout system uses twenty sets of two boards called ADC and connection board. For the sake of a smooth building process all elements were produced in 10% excess, making in total around 7300 objects.

The production is actually spread among several laboratories from research institutes and industries in Europe. For instance, while the individual components of modules are tested in Strasbourg, the module itself is assembled in Paris, then tested again in Strasbourg and eventually fixed on its supporting ladder in Nantes. To cope with all these geographical movements and changes of object status, it was decided to store this information in a database accessible by every actor of the project.

On top of that, to produce a detector of this scale, with the best quality achievable, requires to set qualities for individual constituents and sort among them, the goal being to evaluate the number of good channels and to calibrate them. It is obvious that this task for a half million channels detector can only be done through a computerized system which can store all characteristics of all objects of the SSD.

The database system[1] was then designed with the following main requirements:

- store all characteristics of all objects involved in the building of the SSD in a central place,
- give access to these data to all actors through a web interface,
- allow the geographical and status follow-up of objects,
- display data in simple tables or graphics if needed,
- allow elaborate search through objects.

In this paper we describe first the architecture of the system, then we review all the facilities available to the users and administrators and finally we stress some of the applications where this system was used.

2 TECHNICAL ARCHITECTURE

In essence the database system has to be a distributed system since many laboratories contribute to the project. Nevertheless, one of the main advantages of a database system is to centralize in a unique place all the data. It was decided to build upon a central one-location database server an open system which interacts with this server from different clients, mainly a web application but also LabView and C programs. This architecture is displayed on Fig. 1. A correlated requirement was that it was preferable to use free packages to avoid to pay for licences for a great number of sites.

The MySQL database system was chosen for its simplicity. It is free and provides interfaces for a large number of application languages: C, JAVA, PHP, even ROOT which is a popular tool among the physicists. In addition it allows secure login to the database as well as an automatic procedure to mirror the data on other servers than the central one.

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[1] http://wwwstar-sbg.in2p3.fr (guest access possible)

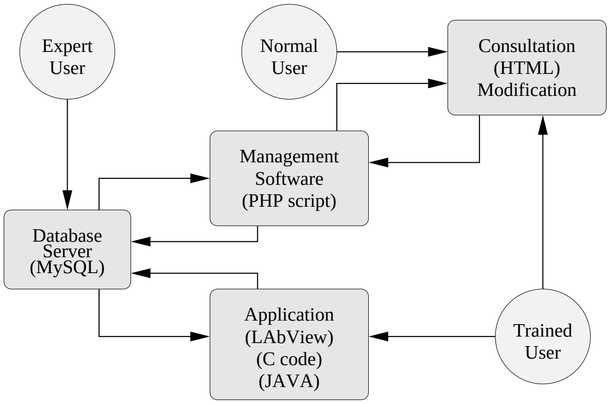

Figure 1: Schematic drawing of the different elements of the database system.

In MySQL data are organized into tables for which we can consider that one entry or line is an object and one column is a property of this object. All the tables needed by the system can be classified in few categories according to their goal. First a few tables are dedicated to administrate the whole project. They contain users and laboratories definitions and their privileges. Then general tables used for all kinds of objects are required to store information like location or status. Two other tables are also useful to all types of object but they fill a specific role. One logs all the changes made in the database, allowing a historical mechanism. The other stores the links between objects (parent-child for objects made of several components). Finally dedicated tables are used for each type of object which properties are not the same.

As stated in the first requirement on this system, tables can contain any kind of data that the production test procedure [2] will generate. Mainly single numerical values are involved here like a current or a voltage. But other kinds of information with a more complex meaning are also used like dead or alive status, graphics in the form of a list of values, position or location (in the form of a string from a predefined enumeration of strings).

From the beginning it was clear that the web will be the main interface, so that the web pages should provide as much facilities as possible. To build HTML pages interacting both with the database server and the user we rely on PHP scripts and JavaScript. A dedicated machine was set up as the central web server for this application. The web pages are mainly dedicated to the consultation of the results but allow also to change some of the properties of objects like location, status and some basic values from tests which are not automatically sent to the database.

The last layer of the system are the programs that allow to enter data directly from the test benches. Most of the tests are automated through LabView Virtual Instruments (VI). There is no direct connection from LabView to MySQL but this difficulty was overcome by using an intermediate C program which is interfaced with MySQL. This little program runs as a daemon on a Linux machine. It receives through TCP/IP socket SQL commands from LabView and then sends them to MySQL. So that only some LabView VIs to build MySQL commands incorporating the data to enter in the database have been created. Alternatively, all LabView VIs also write their data on simple text files with a known format. For every type of file a dedicated C program parses the file and sends the data directly to the correct MySQL tables. This method was actually used at the beginning of the production process.

3 SYSTEM FACILITIES

The very first and readily available pages for consultation after the login step are lists per type of object which show every currently registered item in the database. General information is first displayed in an array with one object per line. From there, the user can access, for a given object, a specific test results window with tables and graphics if some are attached, an editor form to change some of the properties, an assembly window which displays whether the object has some parents or some children and a history window with the log of every change made.

In addition to these simple list displays, it is possible to show on the fly the distribution of any column (properties of the object).

The other main feature is the search engine. On top of the usual search for general properties like name, location or status, a technical search is proposed. It means that for a given type of object the user can build a query to select adjustable ranges for some properties. For example one can look for silicon wafers with a depletion voltage between 25 and 50 volts and a number of dead strips below 3. The result of this search consists of the same kind of list as before with the same facilities. Such a system allows to show detailed distribution for a given type and quality of objects.

Other interesting items proposed in the menu are the summary pages. They review the number of all kinds of objects registered in the database with respect to different properties like location, quality, status. They also provide for each object type the distributions which are particularly important for estimating the quality of the production (distribution of the number of dead strips on silicon sensors for instance).

On these pages one has also access to an always-up-to-date status of the production flow in graphics form. This displays a box for each state/location that the components of the SSD have to go through during the production process. The boxes indicate how many objects are in such a state allowing to judge whether the production flow is in good shape or if there is a critical path.

To be complete, we have to mention that the rest of the menu consists of forms to enter new objects, information on the user privileges and preferences concerning the language to use (the whole software is automatically proposed in English, French and Polish) documentation on the project, version of the software and a 'how to' section.

4 APPLICATIONS

Such a database system is a powerful tool to precisely characterize a production and even individual objects because it offers both the possibility to average values on the whole sample of data and to pinpoint individual parameters for a given object. Let us illustrate this point by considering silicon sensors for which an important property is the depletion voltage at which it starts to operate properly (good signal to noise ratio). This voltage can only be set by viewing a two dimensional histogram like leakage current versus voltage where a clear break in the curve occurs at the depletion. A dedicated JAVA applet, connected to the MySQL server by means of the Java DataBase Connectivity interface, has been built to display this plot along with a cursor that the user can fix at the depletion point. This point is then stored in the database as the depletion voltage. This method was known to work but it was possible to tune it on a large sample insuring a precise determination of the depletion for each detector.

Another example of the benefit of the system is the possibility to set a quality for each object. This quality serves then as the primary characteristic to decide to accept (pay) the object from the producer and to insert it in the SSD. Using the technical search allows actually to check how many objects of a given type will fulfill some criteria, then make some distributions to help in tuning the selection. Once the quality is defined, a simple C code incorporating the selection updates the quality value for each object.

As explained in the introduction, the SSD production phase is still going on. Thus it is clear we have not yet created all the needed applications. The last example worth describing is the way we have chosen which sensors will go in which place in the detector. Each of the 440 detectors produced and tested exhibits different characteristics. Consequently it is highly desirable to distribute wafers by groups of 16 on ladders carefully. For instance, in order to be able to operate one ladder at a given voltage, detectors with similar depletion voltage should be gathered. It is also important to avoid the creation of large dead zones by spreading as much as possible dead strips. To perform such a choice the powerful C++ interpreter analysis framework of the ROOT package was used. A dedicated ROOT macro to read the crucial characteristics of all sensors from the database and then distributes them among ladders while checking the property of ladders (bias voltage, dead strips,...) remains in the specification.

5 CONCLUSION AND OUTLOOKS

The creation of this database system started a little bit earlier than the production phase of the SSD itself. The core packages have been created in a few months by a very restricted team of developers. Then it got enriched by user feedback and new requests. This process of requests from detector testers to the developer is going on for more than a year and is necessary for each new phase the production.

The final application of this system will be to provide the most complete and detailed technical status of the SSD once produced and installed in STAR. It will serve as the primary source of information for the first calibration and condition databases [3] which are required to operate the detector. Meanwhile it will still be available to retrieve the properties of the components during the running life of the SSD.

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7 REFERENCES

[1] The STAR SSD Collaboration, "Proposal for a silicon strip detector for STAR", STAR note SN-0400, June 1999.

[2] J.R. Lutz et al., "Production tests of microstrip detector and electronic front-end modules for the STAR and ALICE trackers", Proceedings of the 5^{th} workshop on electronics for LHC experiments, Krakow, Sept. 2000.

[3] D. Bonnet et al., "Control System of the silicon microstrip layer of the STAR experiment", Proceedings of the ICALEPS'99 conference, Trieste, October 1999.