CMS Run Registry: Data Certification Bookkeeping and Publication System

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Abstract. The Run Registry of the CMS experiment at the LHC is the central tool for the tracking of the data quality monitoring and data certification workflows and the bookkeeping of the results. It consists of a Java web application frontend which connects to an Oracle database in the backend. The current production version 2 of the Run Registry application, was deployed in the beginning of the year 2010, before the LHC data taking started, and has since then undergone a number of full release cycles. In this note we describe the architecture and the experiences from the first year of datataking.

1. Introduction
The monitoring and certification of the quality of the CMS data consists of a multi-step procedure, spanning from online data taking to the offline reprocessing of data recorded earlier. The quality assessment is based on both visual inspection of data distributions by monitoring shift persons as well as algorithmic tests of the distributions against references. The Run Registry (RR), reported here, is the central workflow management and tracking tool used to certify collected data, to keep track of the certification results and to expose them to the whole CMS collaboration.
The RR consists of a web-based user interface frontend and a dedicated database and includes facilities for the manual input of data quality decisions and the automatic collection of detector and beam conditions, as well as the querying of the data and the export of selected information onto the screen and/or into flat output files of various formats. Among other purposes, is regularly used by the CMS collaboration for the creation of official ‘good-run list’ files which are used as input to downstream selection of the data for reprocessings and for physics analyses. Automation of the data input and querying is possible through an API. The web based service is protected using the CERN Single-Sign-On service [1]. Locally, on the Run Registry, an SSL-certificate system is used to authorize users for different roles: read-only, online shift, offline shift or expert. A message board serves as event notification tool (e.g. for change of data taking conditions) and for communication among shift persons at different sites.

2. User interfaces and data integration
To serve as the main CMS data certification workflow support tool, the Run Registry must comply with the following top level requirements:
aggregation and integration of the full set of data required for the certification process and the

good-run list determination;

specialized graphical user (‘shift’) interfaces (GUI) for manual data input and browsing;

generic API for the input/output and use of certification results through external tools

2.1. Shift interfaces

The CMS data taking is at all times closely followed by data quality monitoring shift. The monitoring
shifts regularly perform a number of well-defined steps in order to produce data quality assessment
and subsequently a data certification result [2, 3, 4].

- **Online Data Quality Monitoring** takes place synchronously with the actual production data
taking. Basic information for a given on-going data taking unit (run) is entered in the Run
Registry manually by a DQM shift person and is based on the visual inspection of data
distributions (histograms) and other (algorithmic) quality information.

- **Offline Data Quality Monitoring** is performed as soon as the full set of event data of a given
run has been processed (at Tier-0). The histograms are inspected by an offline DQM shift
person who produces quality decisions (good/bad) based on visual inspection of the DQM
histograms, this way confirming or falsifying the results obtained in the online monitoring
step. Both online and offline monitoring steps are presently subject to automation as shift
person tasks are being replaced by algorithmic tools and watchdog applications where
possible.

- In the **Sign-off** step, the data obtained by the regular online and offline shift persons are
reviewed by the detector and software subsystem experts, and, after possible corrections, the
data are signed off.

- In the **Completed** step the signed-off certification information is frozen in the Run Registry
and the official ‘good run’ list file in JSON (JavaScript Object Notation, a lightweight data-
interchange format) format is produced and distributed to the CMS community for analysis
[5].

The Run Registry provides a single role-based GUI application which is available within local CERN
network. Access to different tools, controls and dedicated workflow steps is granted based on the
user's role. The different roles are separated by workspaces; a user may have different sets of roles in
different workspaces.

The standard CERN Single-Sign-On service (SSO) is used to authenticate users [1]: in order to be
authenticated a user must have a valid CERN account (user name and password) and an SSL-
certificate issued by the CERN Certification Authority (CA) installed in the web browser.

The authorization is based on a role-list stored in the Run Registry. The role-list assigns roles to users
by their name and/or certificate. Possible authorization schemes are:

- **name-only**: for frequent shift persons, experts and administrators
- **certificate-only**: for regular shift persons working at dedicated shift workstations
- **name and certificate**: for longer term shift persons, experts and administrators.

The authenticated user can acquire one or more roles based on the workspace role-list. User roles are
inclusive – if a role extends another one, it inherits all functions along with its own. Available user
roles and corresponding functions are listed in the following:
2.1.1. Non-authenticated user role
This role is for casual users who do not identify themselves to the system. Accessible user functions include read-only functions such as: login, switch workspace, browse data, apply simple and advanced filters, export data to any format, plot charts and read-only access through API.

2.1.2. Authenticated user role
Users who have authenticated themselves to the system by CERN SSO and valid certificates can do everything that a non-authenticated user can do. In addition they can submit user role requests and post messages to message board.

2.1.3. Online shift role
Authenticated users with the role ONLINE, granted either through their user names and/or through local host certificates, can do everything that authenticated users can do, plus enter (‘create’) new data taking information (called ‘online datasets’) in the workspace and move these online datasets to the next state (‘Sign-off’) for subsequent confirmation by detector experts, as explained above.

2.1.4. Offline shift role
Authenticated users with the roles OFFLINE role, granted either through their user names and/or local host certificates, can do everything that authenticated users can do plus create new ‘offline datasets’ to ‘online datasets’ already existing in the same workspace, and move these offline datasets to the next state (‘Sign-off’) for subsequent confirmation by detector and software experts (see above).

2.1.5. Expert role
Authenticated users with EXPERT roles, granted either through their user names and/or certificates, can do everything that both other shift roles can do plus edit and delete runs and datasets (one-by-one or in batch) that are in any state except ‘Completed’.

2.1.6. Administrator role
Authenticated users that have ADMIN roles, granted either through their user names and/or certificates, can do everything that an authenticated user can do plus manage workspace users, i.e. assign roles to users, and manage the workspace run classification schema.

2.2. End-user interfaces and API
The Run Registry provides several views and interfaces to users and user applications for the querying and retrieval of CMS run certification data. There are four tables or views to the Run Registry data model that are exposed to the user or user applications:

- The Run Info Table displays all sequential data taking sessions (runs) that were issued by CMS DAQ. The table includes all major detector configuration properties, i.e. trigger keys and active detector components as well as run-time parameters, i.e. number of events, start and end time, average rate, beam status, etc. This table is the primary source for the online shift person to decide if the run should be considered for quality assessment or not.

- The Runs Table (screenshot in figure 1) shows runs (created by the online shift person) and datasets. The run parameters are mostly taken from the Run Info Table and are filled automatically. The shift person manually provides shift comments, including the run stop reason and other general bookkeeping information. Each run must have exactly one online dataset and can have one or more offline datasets. Each dataset has one detector quality bit (good/bad) and one comments field for each individual detector subsystem which are filled by the respective shift persons.
• The Run-LuminositySection Ranges Table displays DCS (Detector Control System) and beam status information for each significant run dataset. The information is retrieved from the respective conditions databases and aggregated in ranges in order to reduce the number of entries. Each range spans luminosity sections (time units of 23 seconds duration) with identical DCS and beam status parameters.

• The Run-LuminositySection Algorithmic Quality Values Table holds algorithmic values that were produced by a specific detector component module.

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**Figure 1.** Run Registry Runs Table view screenshot.

In the present version of the Run Registry user interface, all tables (or views) except for the Run-LuminositySection Algorithmic Quality Values Table are displayed and browsable through the webserver frontend with appropriate column selection and custom sorting facilities. The tables can be filtered by one or several column values and/or selected using advanced SQL-like queries. Filtered data can be exported in a number of data formats, including XML, text and specialized reports, such as good-run-lists in JSON format. There is a possibility to do cross-table queries. For all four tables (views) data querying and exporting facilities are available through the Run Registry API via the XML-RPC protocol.

2.3. Data integration

The integration schema of the application with external tools/systems is sketched in figure 2 and detailed below:

1. The main run configuration information is retrieved from the DAQ (Data Acquisition) ‘RunInfo’ table into the Run Registry run summary table. The integration is implemented via an Oracle procedure that periodically queries the DAQ tables and creates and updates data in the Run Registry schema. Rows are being transposed to columns on the fly during the update.

2. The Run-LuminositySection information is retrieved from the ‘Run-time Logger’ data into the Run Registry run-luminositysection table. The luminosity section data is retrieved by a periodically running Oracle procedure. The algorithm creates and populates luminosity section data.
ranges based on parameter values. The Run-time Logger applications and tables are maintained by CMS Web-based Monitoring (WBM) team [6].

3. The LHC beam status information is retrieved by a python script that periodically queries the LHC beam status service (XML over HTTP) to retrieve the beam energy, intensities and the fill number and sends the information to the Run Registry via its API. Additionally, the LHC Page One service is queried for the LHC beam status message.

4. The CMS DQM algorithmic run and luminosity section quality values are retrieved from the DQM GUI output root files. Run and luminosity section quality values are sent to the Run Registry through its API. The integration link is implemented in periodically running python scripts. First, the script queries the Run Registry API to retrieve a list of runs that miss algorithmic DQM information and only then it looks for DQM output in the DQM GUI. The LuminositySection quality values are not exposed in the GUI but available via API only.

5. By-run and by-luminosity section certification values are retrievable by custom user applications (mostly python scripts) from the Run Registry through its API [5].

![Diagram]

**Figure 2.** Run Registry integration with other applications. Numbered links are explained in text.

### 3. Technical architecture

From the technical point of view the Run Registry is a traditional Java web application with an object-relational database on the back-end. A constantly changing production environment and experiment requirements implied that the technical architecture of the Run Registry would be capable to adapt
quickly to varying conditions. Below is the list of major technical components that have facilitated the project to prevail in an agile environment:

- The Java Server Faces (JSF) acts as a top level layer web application framework. JSF provides a sufficient variety of mature web graphical user interface (GUI) components for interactive web applications.
- The Hibernate ORM (Object Relational Mapping) acts as an application model layer and is used to map applications to database objects.
- The application layer is composed of a number of Java objects (mainly beans) that implement various algorithms.
- Oracle ORDBMS (Object-Relational Database Management System) is a main RR data storage and, in part, a data integration environment.

4. Conclusions

Right from the beginning of the CMS commissioning and operations the Run Registry served as an active physics data certification test-bed application. To-date, the certification workflows and procedures are fully defined and the tools and infrastructures have proven their reliability. As the result the Run Registry has been accepted as the central collaboration-wide tool for the creation, storage and retrieval of the official CMS-wide data certification results and the creation of good-run lists for physics analysis.

5. References

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