Adding resources to CMS Online monitoring system

Summer student project report

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1 Introduction

The CERN Large Hadron Collider (LHC) is the world’s largest and the most powerful particle accelerator. It is 27 kilometers long and consists of four main experiments with the Compact Muon Solenoid (CMS) being one of them. Such a delicate system has to be under constant supervision, and for this reason a CMS Web-Based Monitoring (WBM) system had been developed. It has not only provided access to the raw data about state of the components, but also to plots for the shift crew members, detector subsystem experts, operations coordinators, for example. This system has become outdated and now has a successor called CMS Online Monitoring system (CMS OMS). However, not all features that were available on WBM have been accessible from OMS and that is mainly the topic of this report.

The tracker report, i.e., DOC (detector on call) report is a regular report on the environmental conditions of the subdetectors like the strip tracker. This report has to be compiled by detector expert on-call shifters (the DOC’s). For illustration, in order to create this report one has to visit several different web pages, set the parameters, download the plots one by one, maybe add some comments and afterwards put everything together in a single pdf (see also Figure 1). Ideally, one would like to have all these plots available in a single place with a semi-automatized process of making DOC reports.

Figure 1: The DOC report template web page (http://ebutz.web.cern.ch/ebutz/cgi-bin/docReport.pl)

2 Goal of the project

The goal of the project was to locate the data from observables in the DOC report template and to create corresponding aggregation and presentation endpoints in the CMS OMS. For details see under
General structure of CMS OMS and Adding resources paragraphs.

3 General structure of CMS OMS

The CMS Online monitoring system consists of two layers - aggregation and presentation layer. Layers communicate using JSON API compliant requests. The aggregation layer is responsible for fetching the data from a global ORACLE database and other sources and forwarding it to the presentation layer. The presentation layer then displays detector information through customizable and handy web interface. It consists of the so-called Pixel Online Monitoring system (POM) - a python-based software that dynamically creates web pages and multiple plots and tables on them. All plots are created using Plotly.js.

![Diagram of database, aggregation layer, and presentation layer]

4 Locating resource data

Up to now some of the data for the DOC report have been obtained using the WBM Condition browser. At first sight it is not clear to which tables and views in a global database is Condition browser connecting to when getting the data. This relation is described in a table called CONDITION_DESCRIPTOR under the CMS_WBM schema in a global ORACLE database (hostname of the database is cmsonr1-s.cern.ch). This table was widely used when locating data for aggregationapi and is noted here for future reference.

5 Adding resources

Altogether 11 resources from the DOC report template (membrane plant flow and pressure, membrane plant dew points, detector dry air dew points, detector dry air flow and pressure, bottle pressure, underground experimental cavern (UXC) dew points, downtimes, high voltage (HV) ramping times, cooling plant humidities, sniffer dew points) have been added to CMS OMS. Namely, the plots and tables are currently accessible from an instance of POM running on TOM server.

In order to fetch the data for these resources 13 endpoints have been implemented in the aggregation layer. Each endpoint in the aggregation layer consists of the following packages and files (ClassName is the example name of a class):

- ClassName
  - ClassName.java
  - ClassNameMapper.java
  - ClassNameRepository.java
Apart from that, for most endpoints the corresponding JUnit tests (JUnit is a unit testing framework for the Java programming language) for ClassName and ClassNameMapper were created. The endpoints added in the aggregationapi connect to cmsonr1-s.cern.ch database in order to get the data (service: cms_omds_adg.cern.ch, port: 10121).

16 probes and 2 pages have been created in the presentation layer. The term probe here refers to creating a python script that fetches the data for a single quantity from the aggregationapi and prepares it for plotting. Also, within the POM system, in ./cgi-bin/probes, text file serverinfo.txt has been created. It contains the information about the sever and the port on which an instance of aggregationapi is running so that one can easily change the location to which the presentation layer connects to.

The goal was to obtain several functionalities from the WBM within the CMS OMS as they were. Therefore, the data is often filtered exactly as it would be in the queries from the previous system. The cutoffs and filters which are applied to the raw data are denoted under plot description option below the graph itself. If the plot description lacks information about the cutoffs and filters it means that the graph is showing unmodified and unfiltered data.

The following list shows all cutoffs and filters applied to the resources from the DOC report. Each item in the list stands for certain presentation endpoint while the parameters upper limit and lower limit describe the applied cutoffs.

- membrane dew point underground gas room 1 (upper limit= -50.0°C, lower limit=-80.0°C)
- membrane dew point underground gas room 2 (upper limit= -50.0°C, lower limit=-80.0°C)
- bottle pressure (upper limit= 8.0 bar, lower limit=0.0 bar)
- detector dry air dew point 1 (upper limit= -40.0°C, lower limit=-80.0°C)
- detector dry air dew point 2 (upper limit= -40.0°C, lower limit=-80.0°C)
- detector dry air flow (upper limit=4500.0 l/min, lower limit= 0.0 l/min)
- detector dry air pressure (upper limit=9.0 bar, lower limit= 0.0 bar)
- membrane flow (upper limit = 4000.0 l/min, lower limit= 0.0 l/min)
- membrane pressure (upper limit= 9.0 bar, lower limit=0.0 bar)
5.1 High voltage (HV) ramping times

The picture below shows the web interface that provides the data for HV ramping times resource. By default, the report is made for the last two weeks (also the default value in the weekly DOC report template). The user has the option to filter by fill, time range and last hours. The page itself shows min/mean/max values of the time to ready variable and prints exceptions details in case time to ready is greater than 2 minutes (request from the DOC report template). On the right side the plot shows distribution of values of time to ready variable against start time for the period noted below the heading. This page relies on the data from already implemented fill resource in the aggregation layer. This resource provides general data about a certain fill, for example, first and last run number in a specific fill, time needed for system to start collecting the data (time to ready), etc.

Figure 2: HV ramping times page on TOM (TOM.CMS is a server on which an instance of POM is running).

5.2 Downtimes

The downtimes page on POM fetches the data using existing downtime resource in the aggregation api. The data is shown in the table format with the option to filter by a group (one can choose between All, UNDECIDED, GENERAL, DAQ, TRIGGER, PWR_SUPPLY, INFRA and LHC in the dropdown menu in the table header). A group field specifies the reason why the system was not collecting data in a particular period of time. For instance, PWR_SUPPLY tag indicates that a disruption was caused by a power supply system, e.g., power cuts. The information on this filtering is shown in the page headline in the brackets next to the title. Filtering by date range, fill number, last hours and run number has been implemented as well (blue options button in the upper left corner of the
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There is also an option to filter by subsystem (text box in the table header). This filtering is implemented to work in real-time as the user is entering the text in the text box. The sum of lost luminosity for the data presented in the table is displayed above it.

![Downtimes page on TOM.](image)

5.3 Sniffer Dew Points

Unlike other resources from the DOC report template, for which the data needed for the plots or tables has already been present in a global ORACLE database, the situation with the Sniffer dew point resource was somewhat different. No relation between sensor descriptor and its alias was noted there. Also, for each sensor there was a separate view containing the data about it. This would lead to either creating several simple endpoints or few more complex ones in the aggregation layer. It was decided to solve this problem by creating the following database objects in the integration database:

- A table **ALIAS2DESCRIPTOR(ALIAS, DESCRIPTOR, GROUP_NAME)** contains relations between sensor aliases and its descriptors. Descriptor names are usually more comprehensible, but aliases are used on a technical level when storing the data in the database. This table has been created under CMS_TOM_ADMIN schema and it is visible from CMS_TRK_R. This was done in such a way due to permission reasons.

- A view **VW_UX5_SNIFER_DEWPOINTS**(DESCRIPTOR, ALIAS, CHANGE_DATE, VALUE_CONVERTED, GROUP_NAME) contains sensor measurements with the most recent sensor dpId for each of the sniffer dew point sensor aliases. This view has been created under CMS_TRK_R account.

The plot named Other presents the data for all but PP1 and external sensors.
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6 Overview of the work

The table below shows resources that have been added to CMS OMS and are accessible from an instance of POM system running on TOM server. The complete code that has been added can be found on https://gitlab.cern.ch/cmspops/pom (for the presentation layer) and on https://gitlab.cern.ch/vkutzner/aggregationapi (for the aggregation layer).

The Resource name column corresponds to the resources from the DOC report template (http://ebutz.web.cern.ch/ebutz/cgi-bin/docReport.pl). The next column specifies a schema and a view from which the data is fetched. The Name of the endpoint column shows what endpoints had to be used/created in the aggregation layer in order to obtain the data for a certain resource from the global ORACLE database. This is a rather technical detail and is noted for future reference. The column aggregation layer used indicates whether or not the aggregation side of the resources has been created (for instance, it might have already been implemented). The term core stands for aggregation endpoints that have already been present in the aggregationapi while the term custom suggests that the endpoint in question has been implemented during this project. The last column specifies the name and location of the script used to fetch and prepare the data in the Pixel Online Monitoring system.
<table>
<thead>
<tr>
<th>Resource name</th>
<th>Table/View</th>
<th>Name of the endpoint</th>
<th>aggregation layer used</th>
<th>aggregation layer</th>
<th>POM script</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membrane plant flow and pressure</td>
<td>CMS_WBM.V.TKPLCS.DRYGAS114</td>
<td>MembraneFlowUGS (UGS stands for underground gas room)</td>
<td>custom</td>
<td>probes/MembraneFlow</td>
<td>MembraneFlowUGS</td>
</tr>
<tr>
<td>Membrane plant dewpoints</td>
<td>CMS_WBM.V.TKPLCS.DRYGAS111</td>
<td>MembranePressureUGS1</td>
<td>custom</td>
<td>probes/MembranePressure</td>
<td>MembranePressureUGS1</td>
</tr>
<tr>
<td>Detector dry air plant dew points</td>
<td>CMS_WBM.V.TKPLCS.DETDRYAIR111</td>
<td>MembraneDewpointUGS1</td>
<td>custom</td>
<td>probes/MembraneDewpoint</td>
<td>MembraneDewpointUGS1</td>
</tr>
<tr>
<td>Detector dry air plant flow</td>
<td>CMS_WBM.V.TKPLCS.DETDRYAIR112</td>
<td>MembraneDewpointUGS2</td>
<td>custom</td>
<td>probes/MembraneDewpoint</td>
<td>MembraneDewpointUGS2</td>
</tr>
<tr>
<td>Detector dry air plant pressure</td>
<td>CMS_WBM.V.TKPLCS.DETDRYAIR113</td>
<td>DetDryAirDewpoint1</td>
<td>custom</td>
<td>probes/DetDryAirDewpoint</td>
<td>DetDryAirDewpoint1</td>
</tr>
<tr>
<td>Detector dry air plant pressure</td>
<td>CMS_WBM.V.TKPLCS.DETDRYAIR114</td>
<td>DetDryAirDewpoint2</td>
<td>custom</td>
<td>probes/DetDryAirDewpoint</td>
<td>DetDryAirDewpoint2</td>
</tr>
<tr>
<td>Bottle pressure</td>
<td>CMS_WBM.V.TKPLCS.MONITOR146</td>
<td>BottlePressure</td>
<td>custom</td>
<td>probes/BottlePressure</td>
<td>BottlePressure</td>
</tr>
<tr>
<td>Resource name</td>
<td>Name of the endpoint</td>
<td>Table/View</td>
<td>aggregation layer used</td>
<td>POM script</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>----------------------</td>
<td>------------------------------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>UXC (underground experimental cavern)</td>
<td>UXC_Dewpoint</td>
<td>CMS_BEAM_COND., CMSX_DSS_ALDEWPOINT_UXC55</td>
<td>custom</td>
<td>probes/UXC_Dewpoint</td>
<td></td>
</tr>
<tr>
<td>Dew points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtimes</td>
<td>Downtime</td>
<td>see QueryBuilder file under <em>Downtime</em> endpoint in the aggregationapi</td>
<td>core</td>
<td>pages/page_downtimes</td>
<td></td>
</tr>
<tr>
<td>HV(high voltage) ramping time</td>
<td>Fill</td>
<td>see QueryBuilder file under <em>Fill</em> endpoint in the aggregationapi</td>
<td>core</td>
<td>pages/page_HVramping</td>
<td></td>
</tr>
<tr>
<td>Cooling plant humidities</td>
<td>FwcavplantSs1Humidity</td>
<td>CMS_WBM.V.TKCP_Ss1_16040_10</td>
<td>custom</td>
<td>probes/Fwcavplant_Ss1_Humidity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FwcavplantSs2Humidity</td>
<td>CMS_WBM.V.TKCP_Ss2_16040_10</td>
<td>custom</td>
<td>probes/Fwcavplant_Ss2_Humidity</td>
<td></td>
</tr>
<tr>
<td>Sniffer Points</td>
<td>SnifferDewPoints</td>
<td>VW_UX5_SNIFTER_DEWPOINTS</td>
<td>custom</td>
<td>probes/SnifferDewPointsPP1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>probes/SnifferDewPointsExt</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>probes/SnifferDewPointsOther</td>
<td></td>
</tr>
</tbody>
</table>
7 Conclusion and future work

11 resources from the DOC report template are now available on TOM.CMS which should hopefully simplify and quicken the process of making DOC reports. For most resources the data was already present in a global database, although one resource (sniffer dew points) required additional views and tables to be created. In the future, it would be beneficial to recreate all the existing WBM tables within CMS_TRK account giving them more sensible names. Also, the next big step after having all DOC report template resources accessible from the CMS OMS is making the process of creating DOC reports semi-automatic meaning that one should be able to set parameters, add comments and download the report in preferred format and all that by visiting just one page.

8 References

- https://gitlab.cern.ch/cmspops/pom (August 2019.).
- https://gitlab.cern.ch/cmsoms/aggregationapi/wikis/home (August 2019.)
- personal communication with Ulf Behrens (mainly for data location issues).
- Presentation layer of CMS Online Monitoring System, Stankevicius, Mantas (Vilnius U.).
- https://docs.python.org/3/tutorial (August 2019.).