INTEGRATION OF THE VACUUM SCADA WITH CERN S ENTERPRISE ASSET MANAGEMENT SYSTEM

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INTRODUCTION

Abstract

With over 128Km of vacuum chambers, reaching pressures as low as in interstellar space, CERN is home to the largest vacuum system in the world. Its underlying architecture comprises approximately 15 000 pieces of control equipment, supervised and controlled by 7 Supervisory Control And Data Acquisition (SCADA) servers, and over 300 Programmable Logic Controllers (PLCs). Their configuration files are automatically generated from a set of ORACLE databases (vacDB) using a Java application (vacDB-Editor).

The maintenance management of such an amount of equipment requires the usage of an Enterprise Asset Management system (EAM), where the life cycle of every equipment is tracked from reception through decommissioning.

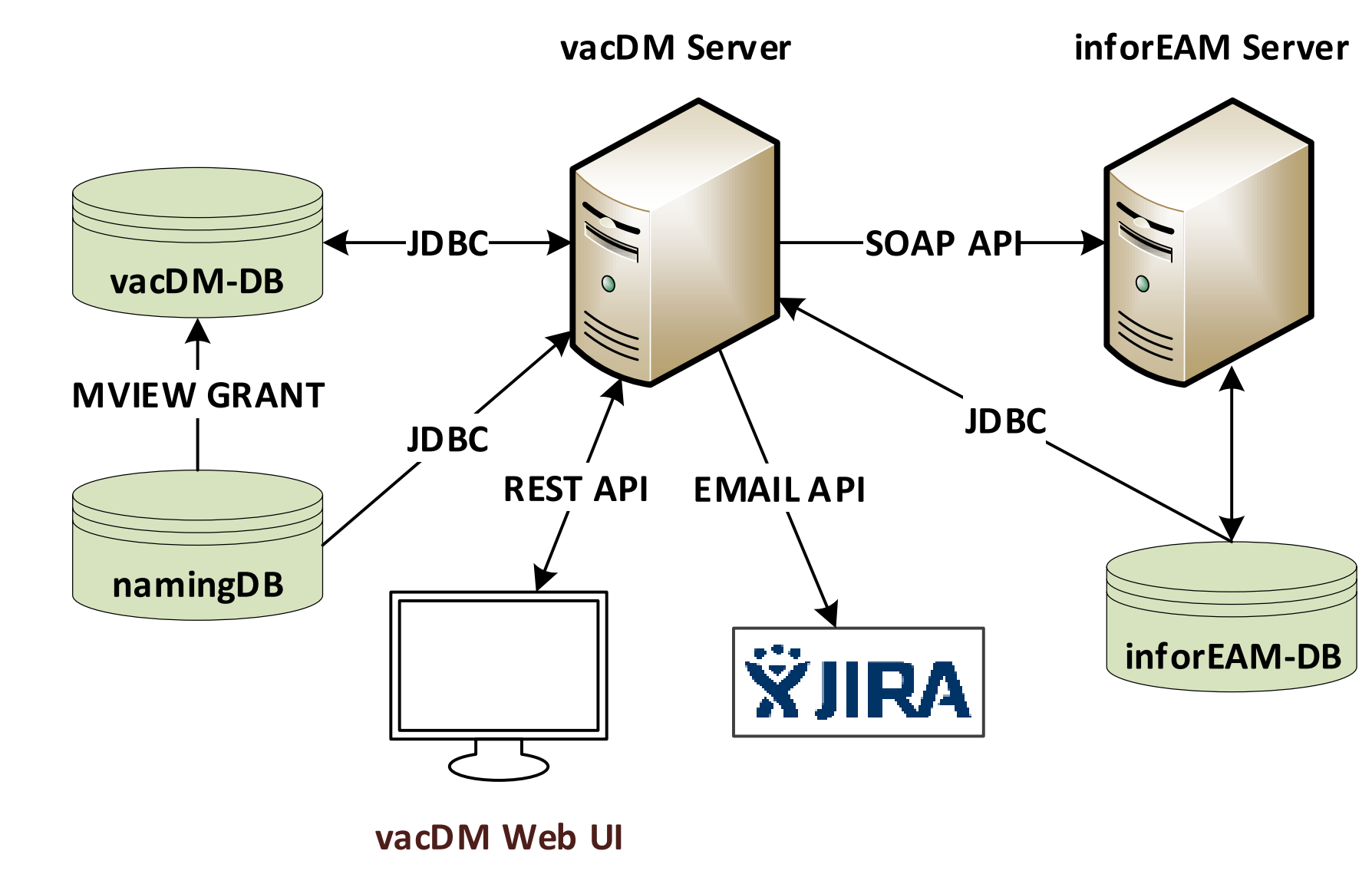
The equipment displayed in the vacuum SCADA is automatically integrated in its user interfaces (UIs) based on data available on vacDB. On the other hand, the equipment available in Infor-EAM (the official EAM tool at CERN) for maintenance management activities (creation of work-orders, stock management, location tracking) resides in its own database. This leaves room for mismatches between what users see on the SCADA and in Infor-EAM. Although manual imports of equipment lists from vacDB to Infor-EAM are possible, the process is time consuming, error prone, and only guarantees the correctness of data while no equipment is added, deleted or modified in vacDB. Aiming to solve this issue, a web-based application called vacDM was developed to ensure continuous consistency between vacDB, Infor-EAM and CERN s dictionary database for equipment descriptions, the naming-DB.

Following the implementation of vacDM, the vacuum SCADA was updated to allow the generation of Infor-EAM work orders.

ASSET MANAGEMENT

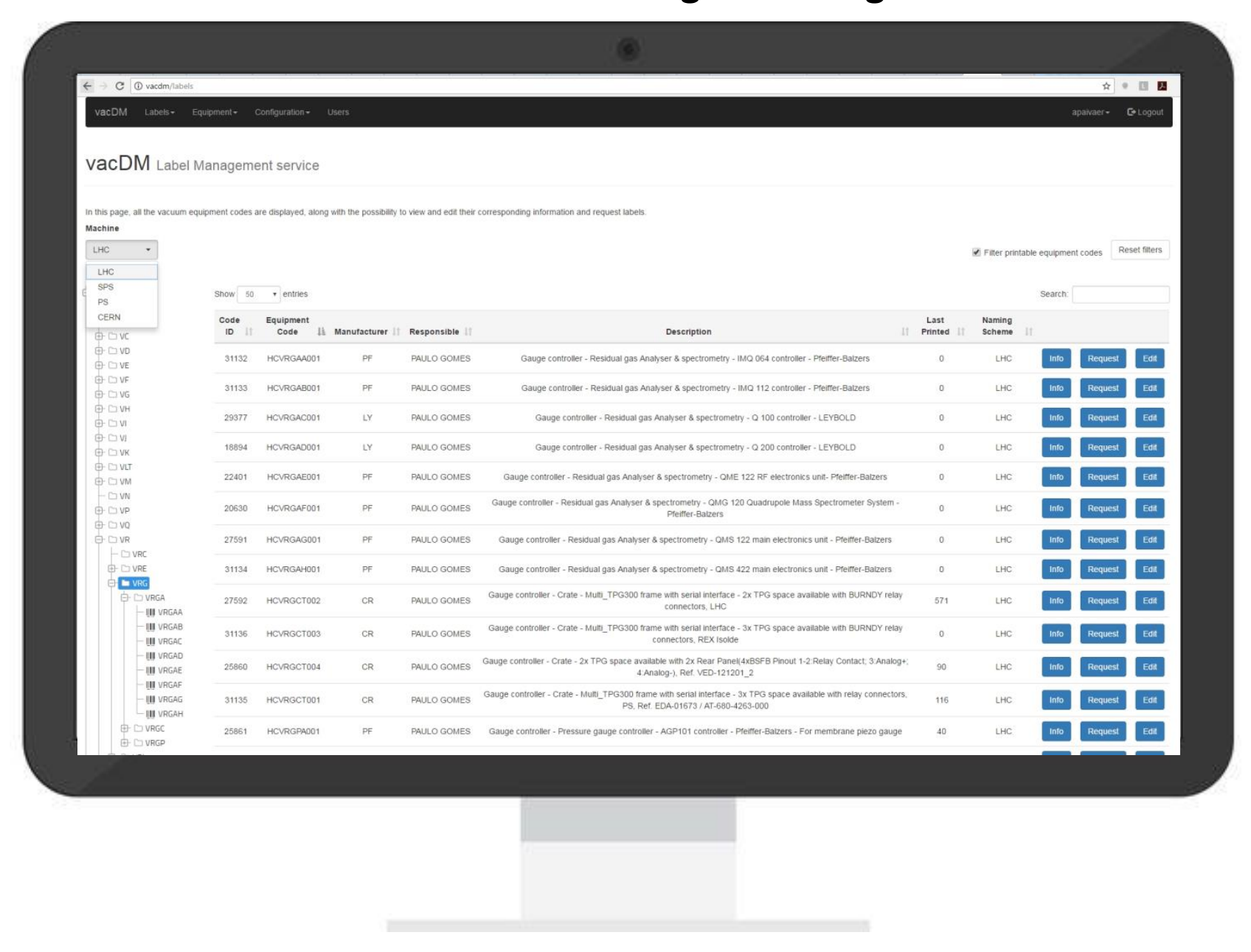
Prior to the usage of vacDM, when new equipment was received or manufactured, an asset code would be generated and a label printed and attached to the device for future identification. The equipment would then be declared in Infor-EAM so that the information about the new asset could be introduced and the device tracked for location and works performed on it.

According to registries held in excel sheets on the number of labels printed for each asset type, it was observed that the number of labels printed did not match the number of assets declared in Infor-EAM by several thousands, posing an issue for the traceability of vacuum assets. It was determined that this issue arose due to the lack of tight linking between the printing of labels and the declaration of assets.

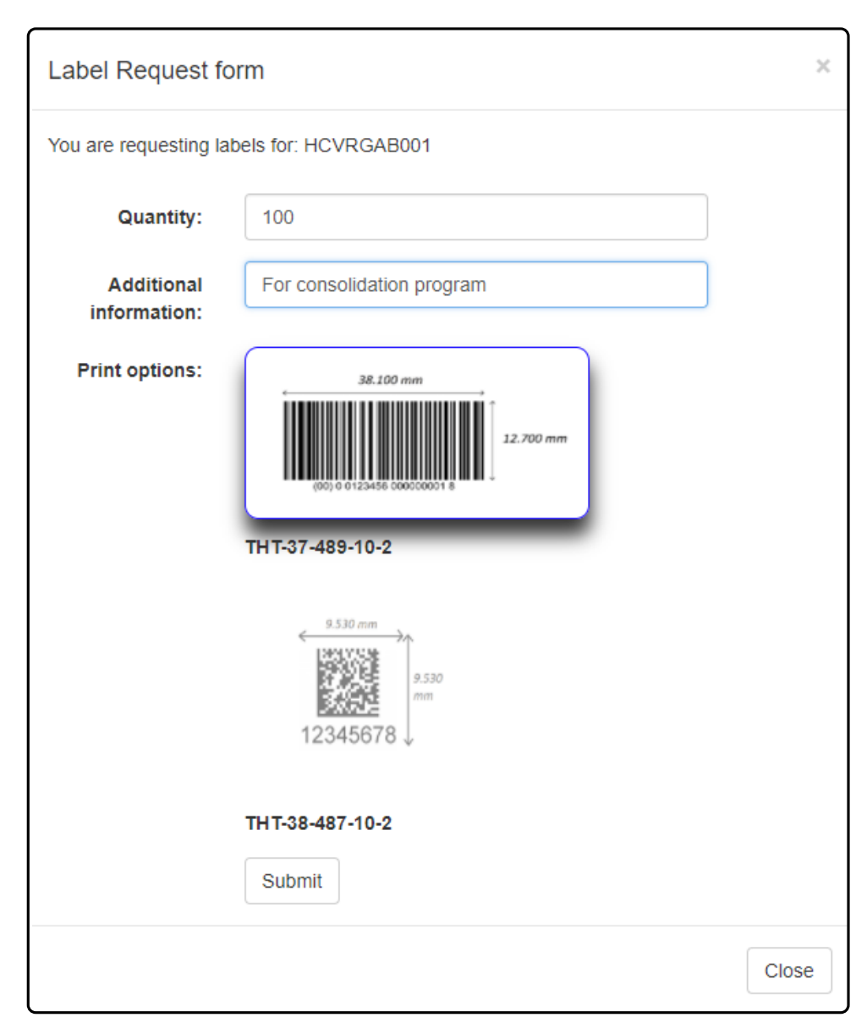


Asset Management subsystem architecture

vacDM Asset Management Page



Label Request form



Label Request form

You are requesting labels for: HCVRGAB001

Quantity: 100

Additional information: For consolidation program

Print options:

THT-27-489-10-2

12345678

THT-38-487-10-2

Submit

Close

Asset Import Modal

Resume import of assets to InforEAM

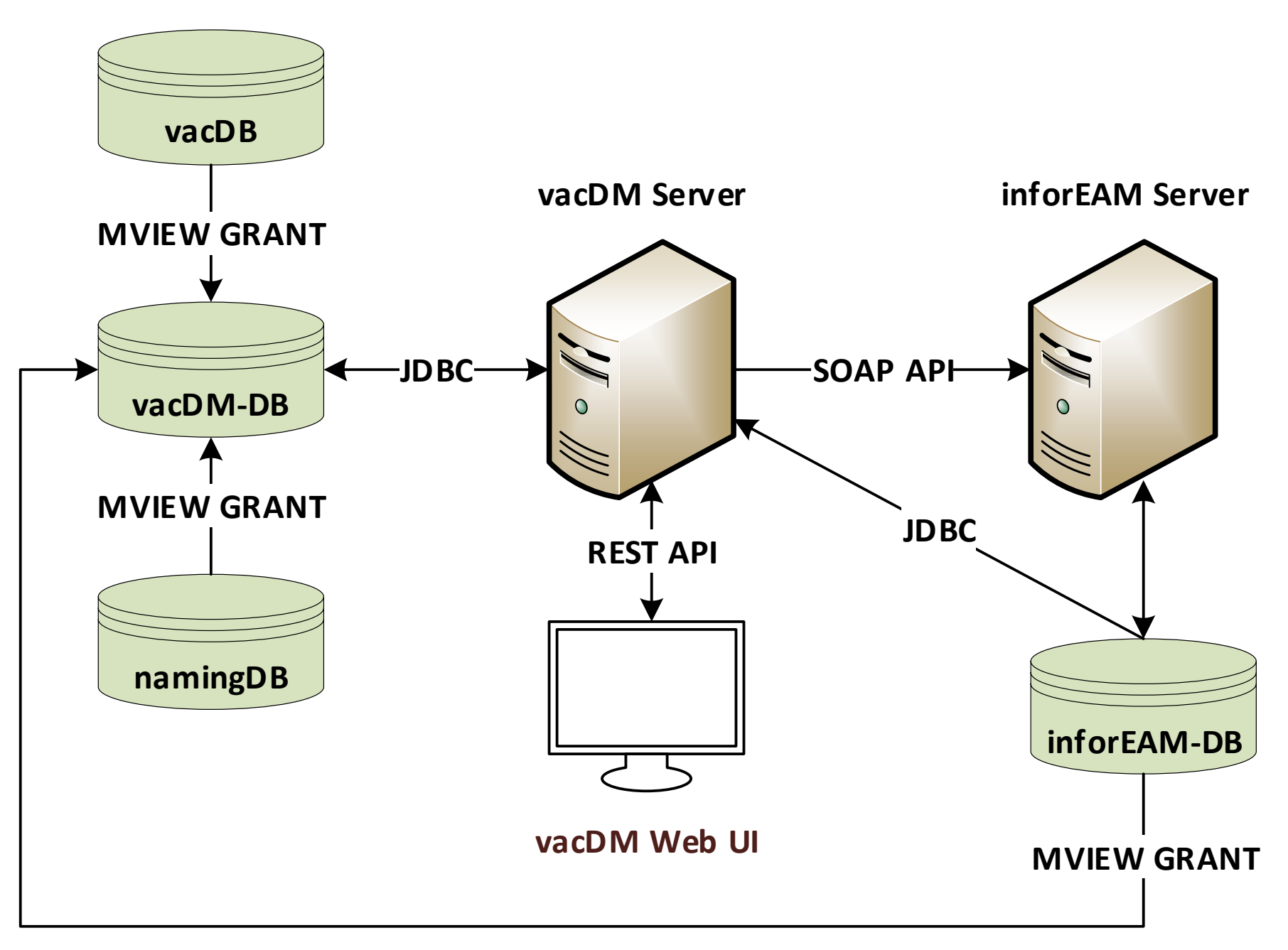
The following 100 assets will be imported:

Via the vacDM web interface, users are able to request labels for new assets by choosing the equipment code. The equipment codes available for label printing are displayed in a tree structure, linked with CERN s naming database to ensure that only official, approved codes, are used.

After a user selects the equipment code and number of assets to be created, vacDM accesses the Infor-EAM database to check the latest asset sequence number printed for this equipment code. The sequences of the new asset codes are then calculated, combined with the official equipment code description for the asset available in the namingDB, and the assets are created using Infor-EAM s SOAP API. In parallel with the creation of assets, an email is sent to the user responsible for printing the labels and a ticket is created in JIRA for the printing job. The historical records of all asset requests, along with the status of the creation attempts for each asset in Infor-EAM are kept in the vacDM-DB. For assets that failed to be created, a further import can be launched.

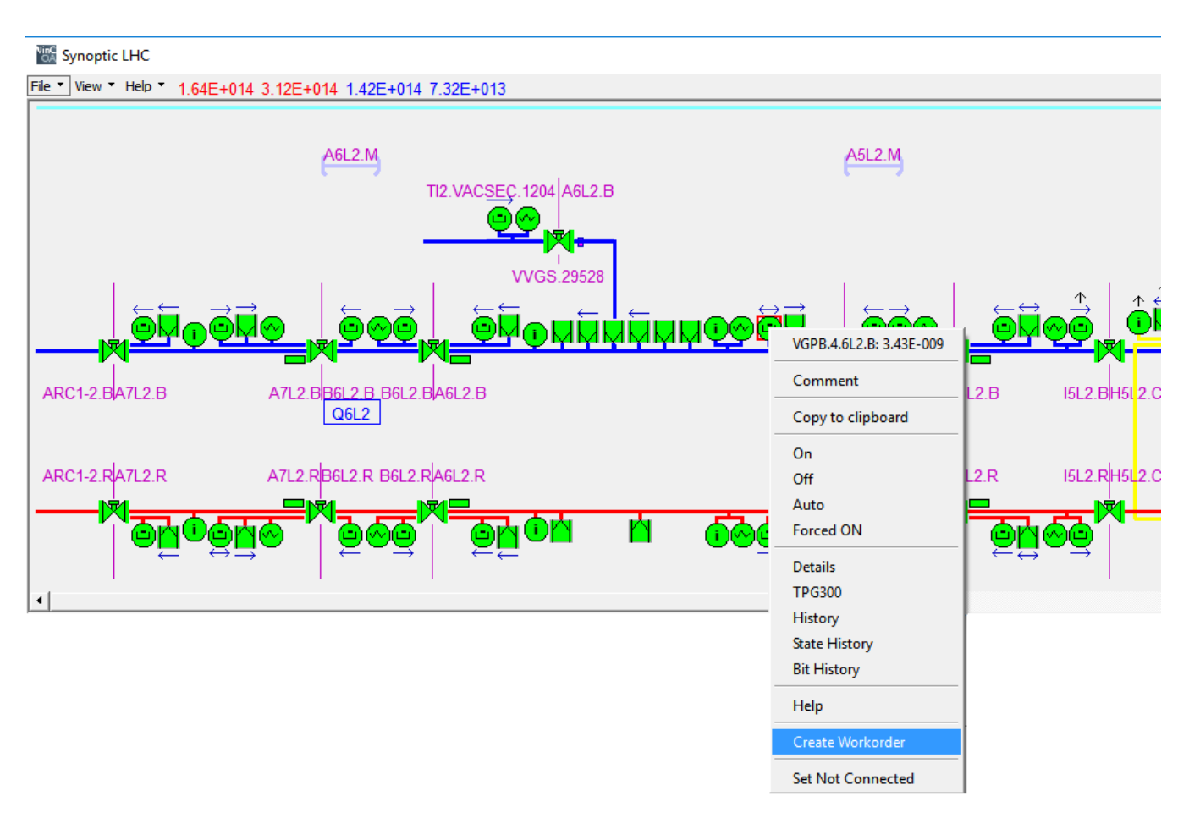
FUNCTIONAL POSITIONS MANAGEMENT AND SCADA WORK ORDERS

For functional positions, the main objective set for vacDM was the elimination of discrepancies between data stored in the vacuum SCADA, Infor-EAM, and the naming portal. To achieve that, a materialized view on the vacDM-DB joins the functional positions declared in vacDB and Infor-EAM-DB, with the equipment code descriptions in the naming-DB. This materialized view provides a transversal view on functional positions data and is used by vacDM to check for inconsistencies between the three databases. This materialized view is refreshed daily or on-demand, and a scheduled job updates Infor-EAM with the differences detected with respect to vacDB or naming portal. A work order generation tool on the SCADA allows users to quickly generate work orders with minimal knowledge of Infor EAM.

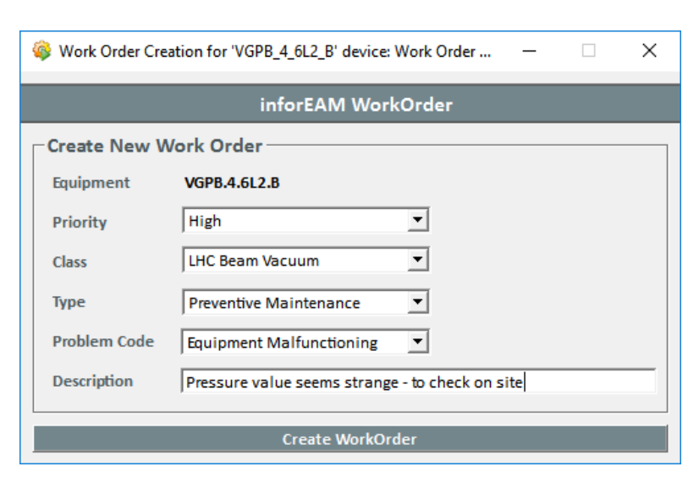


Functional Position subsystem architecture

Vacuum SCADA synoptic



Work Order Creation Panel



Work Order Creation for 'VGPB_4_6L2_B' device: Work Order ...

inforEAM WorkOrder

Create New Work Order

Equipment: VGPB.4.6L2.B

Priority: High

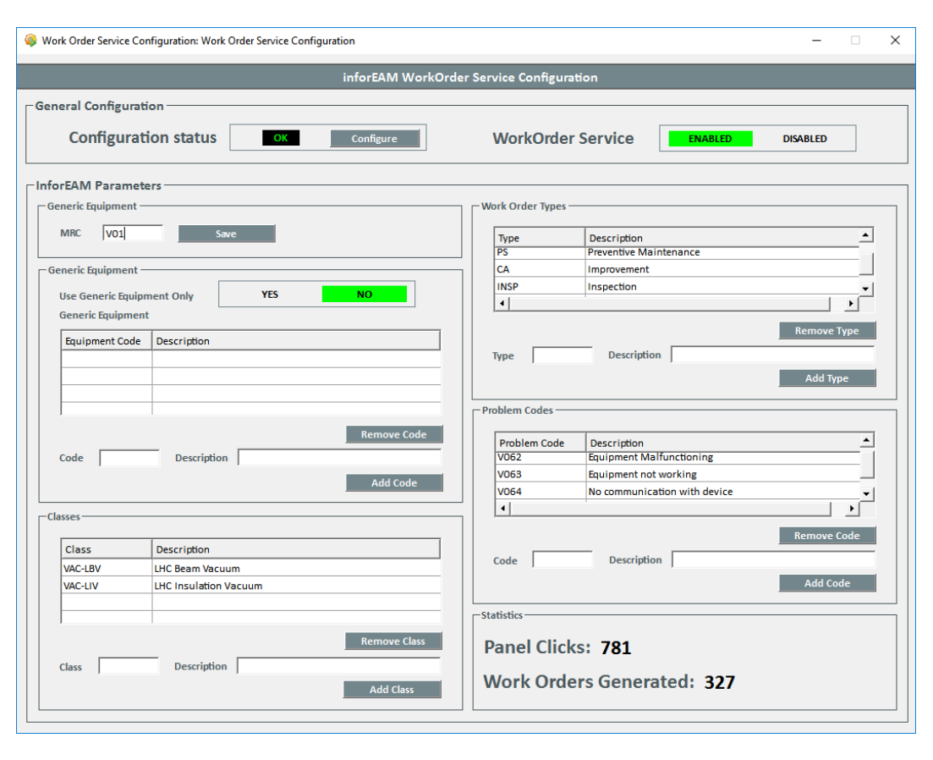
Class: LHC Beam Vacuum

Type: Preventive Maintenance

Problem Code: Equipment Malfunctioning

Description: Pressure value seems strange - to check on site

Create WorkOrder

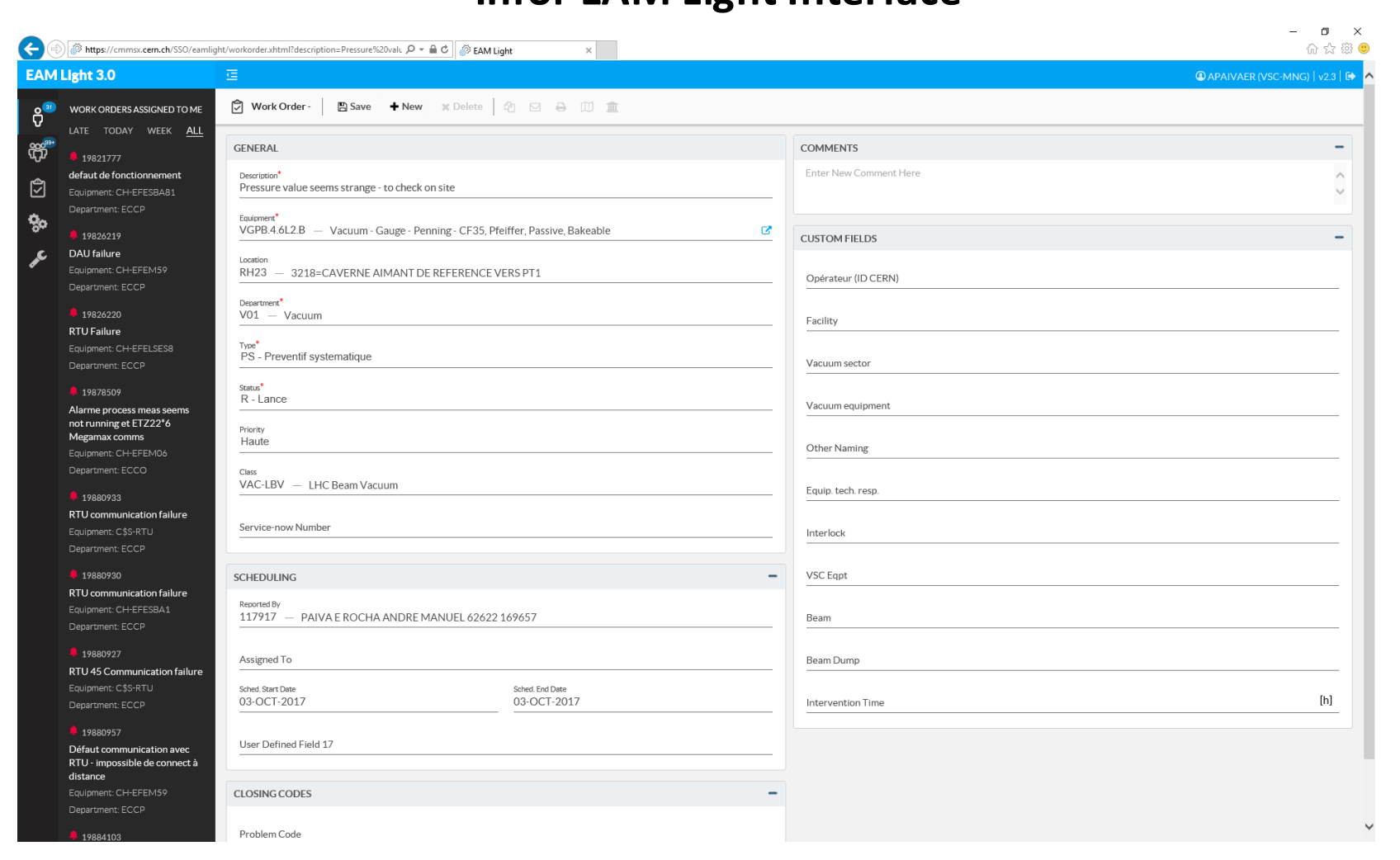


Panel Clicks: 781

Work Orders Generated: 327

Work Order service configuration panel

Infor EAM Light Interface



ARCHITECTURE AND TECHNOLOGIES

The vacDM application is built around the Spring Framework and therefore, it inherits many of its architectural traits, having been developed into a four-tier archicture, composed of the presentation, business, persistence, and database layers.

Presentation Layer

The presentation layer is responsible for the visual part of the application. It runs partially on the web-server and partially on the client s server. Once the static content of the webpage is rendered by the server and sent over to the client, the client then issues web-service requests to get, update and delete data, according to the user inputs.

In the presentation layer, vacDM makes use of the Apache Tiles view resolver on the server-side and of Bootstrap, CSS, Jquery and Javascript on the client-side to handle the aspect, animations, and API requests to the backend server.

Business Layer

The business layer implements spring controllers for handling web resources, restful web-services, and general business logic. After receiving an HTTP request, the business layer controllers might access data-access object (DAO) functions in the persistence layer to get database data. After the data is processed according to the business logic and, depending on the requested URL, the business layer controllers return a view, later processed by a view resolver on the presentation layer, or JSON objects that will trigger a renderization of the concerned module on the client s browser.

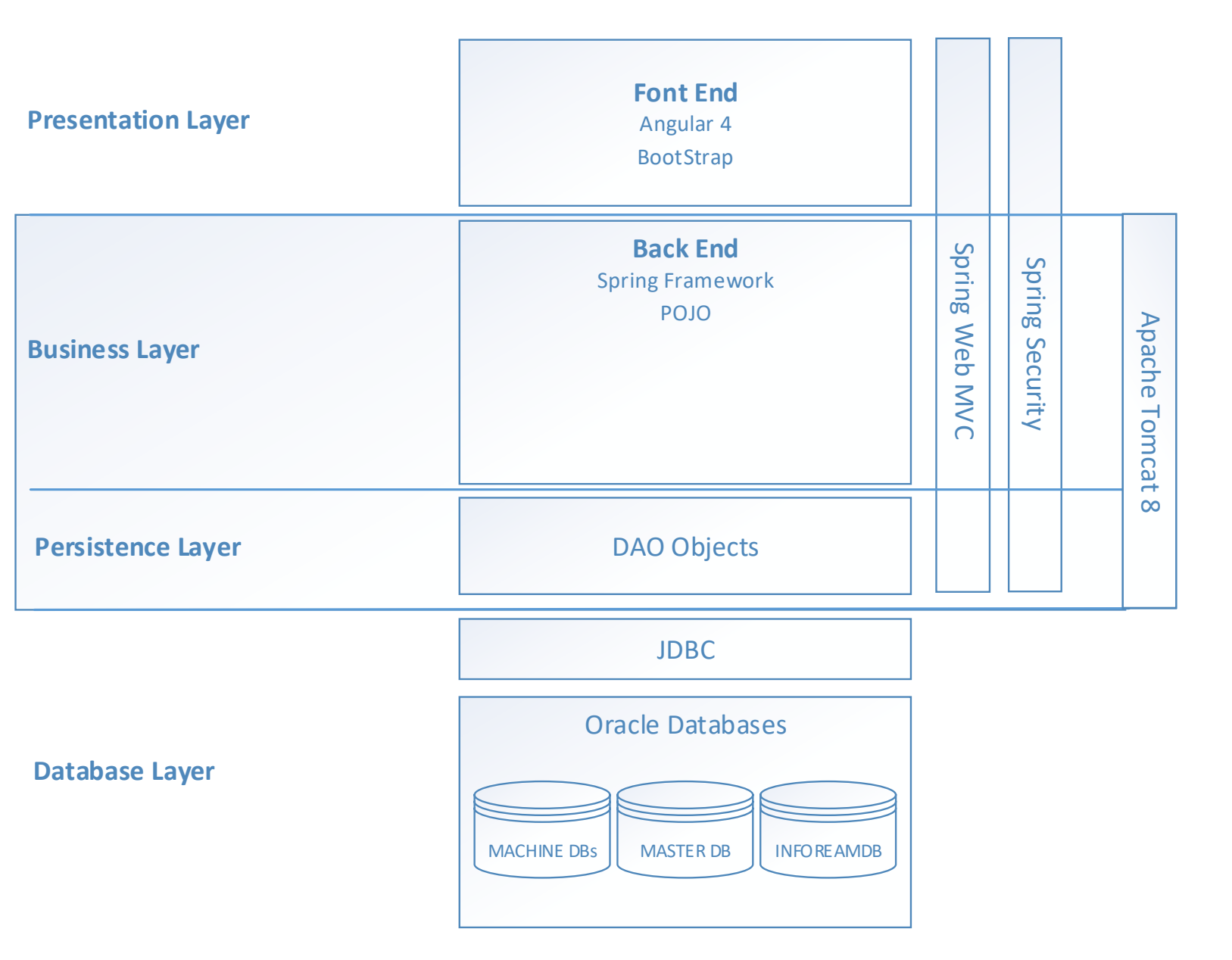
Persistence Layer

The persistence layer implements the DAO objects that provide abstraction to the business layer of the database details. The classes in this layer follow the DAO pattern, providing a Java interface to the business layer, and allowing an easy swap of the implementation classes in case needed.

Database Layer

The database layer is composed of Spring JDBC template beans and CERN hosted ORACLE databases. DAO classes access database parameters through the Java Naming Directory Interface (JNDI).

vacDM Architecture



Security

The application is secured using Spring Security, a Spring module that provides the backbone for managing authorization and authentication, being customizable to address specific user needs. The vacDM spring security module was customized to obtain user authentication from CERN s active directory database. This was done to avoid the duplication of accounts between CERN s infrastructure and the vacDM service.

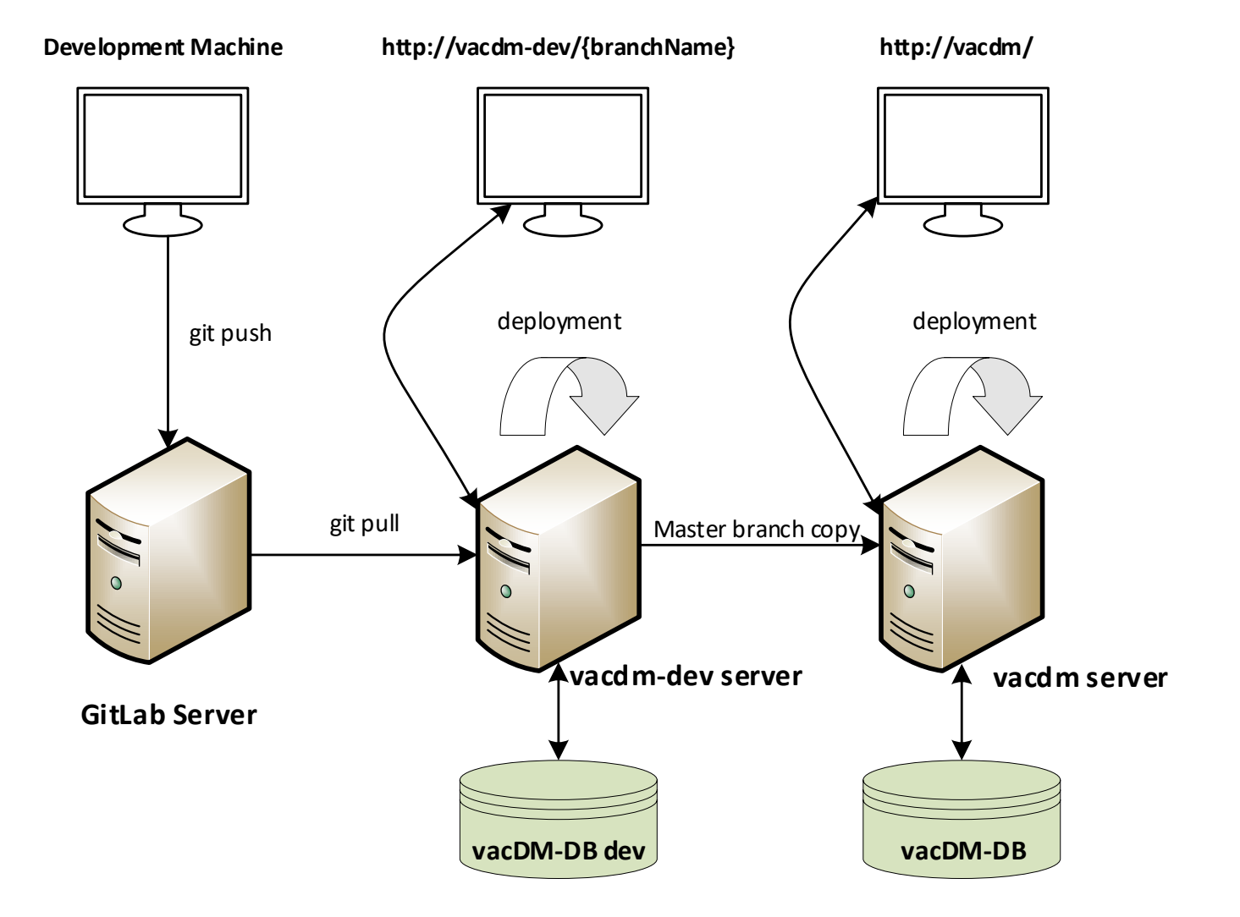
For authorization, vacDM implements a concept of user roles. A set of roles is associated with each user, being the roles what defines which pages or web services the user will have access to.

Out of the box and with minimal configuration required, spring security provides a login/logout mechanism, and protection for cross-site request forgery (CSRF), session fixation, and the ability to secure the application at the method level.

DEVELOPMENT STRATEGY

In order to minimize the risk of propagation of software faults to the production server, a continuous integration pipeline was set up using a continuous integration (CI) server (replica of the production server) and the gitlab platform. After every *git push*, the vacDM CI server pulls the affected branch, runs units tests, builds the application using maven, and deploys it locally to http://vacdm-dev/{branchName}. This allows developers to test their feature branches in an environment similar to the production server.

All *git push* commands on the master branch are automatically deployed to http://vacdm-dev/, allowing developers to test the next release of the application. From Gitlab s user interface, developers can trigger an automatic deployment to production. Upon a deployment to production, the CI server stops the tomcat service on the production server, copies the web application and restarts it. This enables an application deployment in less than a few minutes.



CONCLUSION AND FUTURE WORK

Conclusion

The first version of vacDM was successfully put in production and is now managing over 9000 pieces of vacuum equipment in the LHC. With no further developments required, the SPS and CPS machines will also be integrated in vacDM, after the completion of an on-going database consolidation campaign. This will enable the vast majority of vacuum equipment to be managed in Infor-EAM, improving the tracking of equipment throughout its lifecycle. After 6 months of usage of vacDM, the number of ghost assets (with label printed, but not declared in Infor-EAM) has been reduced to zero. Similarly, 100% of the SCADA functional positions targeted to be managed in Infor-EAM have been successfully imported.

Future Work

To ensure further consistency with CERN s layout database, vacDM needs to be updated to also import layoutDB names as aliases on the equipment it creates in Infor-EAM, along with the database links between Infor-EAM and layoutDB, to allow the navigability between the layoutDB portal and Infor-EAM.

On the SCADA side, several new features will be developed to improve the user experience: direct links from the equipment menu in the SCADA to the layoutDB webpage, direct links from the equipment menu in the SCADA to the Infor-EAM Equipment webpage and an automatic work order creation feature upon detection of abnormal conditions, such as equipment failure and overpressures.

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