

REMUS: THE NEW CERN RADIATION AND ENVIRONMENT MONITORING UNIFIED SUPERVISION

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Abstract

The CERN Health, Safety and Environment Unit is mandated to provide a Radiation and Environment Monitoring SCADA system for all CERN accelerators, experiments as well as the environment. In order to face the increasing demand of radiation protection and continuously assess both the conventional and the radiological impact on the environment, CERN is developing and progressively deploying its new supervisory system, called REMUS - Radiation and Environment Monitoring Unified Supervision.

This new WinCC OA based system aims for an optimum flexibility and scalability, based on the experience acquired during the development and operation of the previous CERN radiation and environment supervisory systems (RAMSES and ARCON). REMUS will interface with more than 70 device types, providing about 3,000 measurement channels (approximately 500,000 tags) by end 2016.

This paper describes the architecture of the system, as well as the innovative design that was adopted in order to face the challenges of heterogeneous equipment interfacing, diversity of end users and non-stop operation.

INTRODUCTION

Radiation Protection and Environment Monitoring of CERN facilities and experiments are essential for three reasons:

- Safety of the workplace and of the environment.
- Reporting to authorities the nature and the quantities of emitted ionizing radiation.
- Reporting to authorities in case of pollution of the environment.

In order to fulfil those missions, CERN has set up diverse monitoring equipment across CERN area and its immediate surroundings.

Since 2005, RAMSES (RADIATION Monitoring System for the Environment and Safety) [1] has been in charge of the data acquisition, control/command and supervision of 50 device types, allowing the supervision of 1,500 channels. The former radiation monitoring system, ARCON (AREa CONTroller), is also still in charge of the majority of the monitoring in PS (Proton Synchrotron) accelerator complex. Additionally, proprietary supervisors such as Berthold MEVIS handle the data acquisition and supervision of devices that have not been integrated into RAMSES Supervision. Numerous devices are also operated without any remote supervision.

In 2012, the development of a new SCADA system, REMUS (Radiation and Environment Monitoring Unified Supervision) began. This system aims to:

- Cover a larger set of equipment than RAMSES, in order to unify the supervision and integrate stand-alone devices, most of them being COTS (Commercial Off-The-Shelf) products.
- Provide a reliable, scalable and cost-effective system.
- Use common CERN software, WinCC OA (WinCC Open Architecture) [2], formerly known as PVSS, and JCOP framework (Joint COnTrols Project) [3], for the development and support of the new SCADA.
- Reduce the delay and the cost of adding new devices to the supervision.
- Provide light and fast clients, adapted to the needs of diverse end-users.
- Reduce the overall maintenance and user support effort necessary to maintain the system in operation.

REMUS founded its evaluation of scalability and performance on the study performed by CERN engineering department [4]. The probed technologies are commonly employed in large SCADA systems supervising LHC (Large Hadron Collider) experiments.

For its development, REMUS applies the same International Standard IEC 61508 [5] that was set up during the development of RAMSES.

REQUIREMENTS AND SCOPE

The REMUS project aims at developing a universal software for supervision, control and data acquisition for the entire suite of monitoring stations covering all radiological and environmental parameters that can potentially be affected by the operation of the facilities of CERN.

The functions of the system include:

- Logging of all measured values and system events coming from the instrumentation.
- Providing real-time measured values, alarms and operational states of the devices through customizable user interfaces composed of synoptic and widgets.
- Publishing alarms and faults of the devices to a remotely accessible user interface and to the CERN central alarm system, LASER (Lhc Alarm SERVICE) [6].
- Publishing a selected set of measurements to other systems via the CERN Data Exchange system, DIP (Data Interchange Protocol), built on the top of DIM (Distributed Information Management) [7].

- Logging of a selected set of measurements to CERN shared MDB (Measurement DataBase) [8].
- Remote sending of commands and operational parameters, while recording their changes.

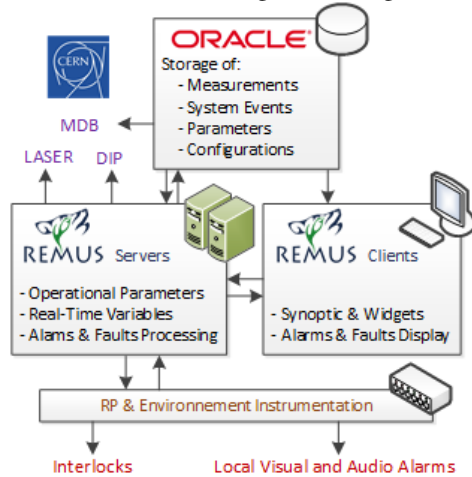


Figure 1: REMUS Functional Diagram.

The system shall monitor the instrumentation 365 days a year, 24/7 and ensure the logging of measured values and system events in case of network outages.

Local safety functions, such as interlocks and visual and audio alarm devices are kept to a low level, independent of the supervision.

HANDLING HETEROGENEOUS DEVICE TYPES INTEGRATION

Devices connected to REMUS come from various manufacturers. Uniform protocols and architectures can therefore not be reasonably expected from the 70 device types that need to be interfaced. Furthermore, many of those devices were not yet selected from the market at the time the development of REMUS began.

Model and Basic Concepts

One approach would be to encapsulate those diverse protocols into heavy middleware infrastructures, but this could lead to a degradation of the performance and has the disadvantage of adding complexity to the architecture, therefore increasing the maintenance cost. In addition, it creates dependencies to the infrastructure and makes the full system harder to be deployed in a different context, for example in a different laboratory for the supervision of temporary experiments.

The innovative approach chosen by REMUS makes an abstraction of this complexity by using a generic model, applicable to any kind of instrumentation, in order to provide the SCADA a uniform set of instruments to monitor (See Fig. 2).

REMUS proposes 3 basic concepts:

- Channel: An abstract entity representing one and only one point of measurement at a specific location, connected to a device.

- Device: A piece of equipment of a determined type (Electronic boards, PLCs, Ionization chambers ...) holding its own parameters, eventually connected to other devices and channels.
- Monitoring Station (MS): An encapsulation of a set of devices and associated channels, connected to the system through a driver.

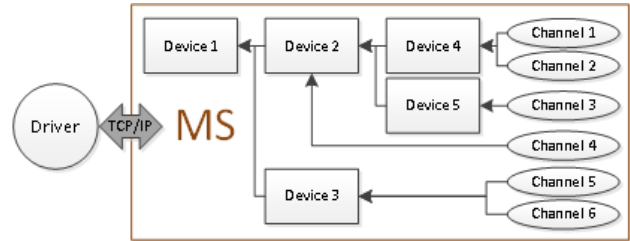


Figure 2: REMUS Instrumentation Model.

Each device type to interface is then modeled in an external Oracle Database using those three concepts, providing a uniform set of equipment to the system. This approach is flexible enough accommodate any radiation and environment monitoring device in the market. It homogenizes the software, makes most of source code reusable and simplifies the development process, from analysis to tests and validation.

Run-time Declaration of New Devices

Using the model previously described, declaring a new device of a known device type in the supervision is equivalent to creating a new instance of the model previously defined, and associating it to a driver. This process is done directly through a WinCC OA User Interface. The new instance is created in the REMUS Oracle Database that REMUS SCADA uses as a reference for the creation of its internal variables, which will hold all the necessary data coming from the equipment in real time. This entire process of instantiation can be executed during run-time and does not requires any restarting of the REMUS servers. Run-time declaration, creation and commissioning of a new device is a function of the system, tested and validated as such, allowing REMUS to be maintained in normal operation 365 days a year, 24/7.

This mechanism, associated with an adapted access control policy, allows users to declare new devices of a known device type in the system, without any intervention of the REMUS maintenance team, reducing the user support effort significantly.

DIVERSITY OF USERS

One of the particularities of the system is its diversity of users. Indeed, REMUS shall provide interfaces for accelerator operators of the different CERN accelerators and experiments, radiation protection engineers, environmental engineers, physicists & maintenance teams.

Furthermore, instrumentation is frequently moved, dismantled or installed, due to the nature of CERN and its

large scope of experiments. Thus, user interfaces need to be adapted to each category of user and flexible enough to allow run-time evolution.

REMUS presents to the users a tree-structured set of synoptic representing CERN surface and underground areas. Widgets representing monitoring stations and channels can be displayed on the synoptic. Several versions of widgets are available for each device type in order to display the appropriate level of information to the final users.

REMUS Applications

In order to provide each user the most suitable interface, REMUS allows the definition of several sets of synoptic and widgets, called *Applications*. Applications represent a sub-set of the supervised instrumentation, with a specific access control. Advanced users having the appropriate access rights can create their own applications for the needs of their team, choosing the synoptic, channels and monitoring stations to be displayed.

REMUS applications are stored in xml files, editable through a user friendly interface, the *Application Editor*, developed by the REMUS team. This feature, added to the run-time definition of new devices, allows advanced users to add a new device to the supervision and make it accessible to the appropriate users without having to go through a heavy procedure, and without intervention of the REMUS maintenance team.

The outcomes of this strategy are positive in three ways:

- Users can focus on the devices they are interested in (only a sub-set of the total instrumentation). For example, some of the applications only display the monitoring of a specific accelerator or experimental area.
- The performance of the clients is improved, as only the variables displayed in the current application are fetched from the servers.
- The maintenance effort is separated among several *Application Administrators*, close to the needs of the users, who are not manpower of the REMUS maintenance team.

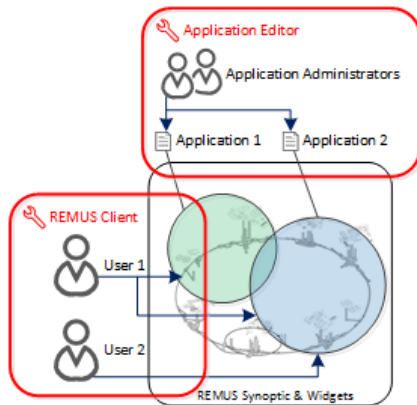


Figure 3: REMUS Application definition and usage.

ARCHITECTURE

As a safety system used by CERN not only during accelerators operation, but also during shutdowns, REMUS needs to be as resilient as possible. The architecture put in place (See Fig. 4) allows the continuous availability of the SCADA, during maintenance operations, deployments, or in case of failure of one of its components.

Connection of the Devices to WinCC OA

REMUS implements five ways to connect devices to the SCADA, depending on the protocol implemented on each device type:

- WinCC OA native driver
- JCOP driver
- In-house developed driver on top of WinCC OA API
- File exchange system
- OPC Server + OPC Client

The choice of driver/middleware type depends on the capacity of the device, as well as the cost of development and maintenance.

Data Acquisition & Archiving

The devices connected to REMUS provide about 170 measurements per second (700 at project completion). For performance reasons, the approach that was chosen is to generate homogeneously formatted measurement files, at the lowest possible level (Device, Driver or WinCC OA control managers), and then inject them to the REMUS Oracle database through SQL*Loader.

This mechanism allows devices and intermediate file servers to store the measurement data in case of network outages in order to ensure the continuity of the data logging.

REMUS Clients

Since WinCC OA has the advantage of being Windows and Linux compatible, REMUS proposes 2 types of clients (Remote UI in WinCC OA terminology) for the users. A load balanced cluster of terminal servers running under Windows Server, accessible from CERN network through remote desktop connections offers a flexible and quick access solution. In addition, Control Rooms can easily access REMUS through their consoles, running under Scientific Linux and already configured to run all the WinCC OA applications developed at CERN.

Redundancy

All the servers used in REMUS architecture are redundant in order to ensure the continuity of the service. WinCC OA integrates a hot standby redundancy feature, including a configurable switching mechanism based on error status evaluation. The less degraded server will be selected as the active server in case of failure of one of the WinCC OA components.

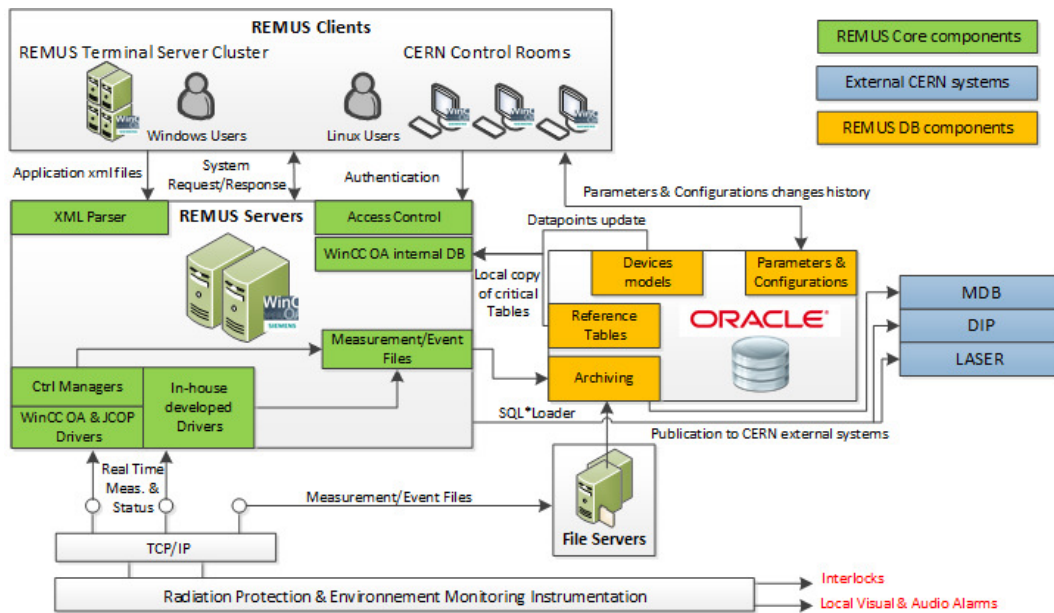


Figure 4: REMUS Architecture.

Oracle Database Failure Handling

Aside from the archiving of measurements and system events, REMUS uses an external Oracle database in order to store device models and history of device configuration and parameterization changes. It also uses Oracle tables as a reference for the list of available measurement units, email addresses, phone numbers to send notifications to etc.

In order to provide the full SCADA functionality in case of unavailability of the Oracle database, REMUS stores critical information into the WinCC OA internal database, based on RAIMA technology [9]. In addition, all statements that should have been executed during this unavailability, like the changes of a device parameters, are stored temporarily in the same internal database and executed when the Oracle database connection is re-established.

CONCLUSION

Relying on technologies widely used and probed across CERN, REMUS achieves its main objective to unify all Radiation Protection and Environment Monitoring systems into one reliable, scalable, flexible and cost-effective solution.

Implementing innovative concepts that handle issues revealed during the development and operation of previous supervisory systems used in the CERN Health, Safety and Environment Unit, REMUS offers a long term prospect.

In continuous operation and development since 2013, the project has received very positive feedback from its users. Its light architecture and easy deployment have opened the possibility of collaboration with other laboratories and industrial partners, who have been interested in the project since its early stage.

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