TIP: AN UMBRELLA APPLICATION FOR ALL SCADA-BASED APPLICATIONS FOR THE CERN TECHNICAL INFRASTRUCTURE

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Abstract

The SCADA package WinCC Open Architecture (WinCC OA [1]) and the control frameworks (JCOP [2], UNICOS [3]) were successfully used to implement many critical control systems at CERN. In the recent years, the Industrial Controls and Electronics (ICE) group of the Engineering Department (EN) at CERN, supported other groups to re-implement the supervision of technical infrastructure, like Electrical distribution (EL), and Cooling and Ventilation (CV), using these tools. However, the fact that these applications are highly independent from the operation point of view, as well as their increasing number, renders operation uncomfortable since shifters are forced to continuously switch between them. In order improve the integration, EN-ICE is developing the Technical Infrastructure Portal (TIP) to provide centralized access to all WinCC OA applications, and extending their functionality including links to external databases and to a powerful localization system based on GIS. In addition the tool offers an environment for operators to develop views that aggregate data from different sources, such as cooling and electricity. This paper also describes the challenges faced during the implementation of TIP due to the large degree of heterogeneity across applications, although they are made out of common building blocks.

INTRODUCTION

For the construction phase of the LHC, a big emphasis was put in the use of industrial tools for the control systems. This was complemented with the development of frameworks that provided the necessary adaptations to the CERN environment (JCOP, UNICOS). This approach showed to be very successful and many systems were built following it in both the experiments (e.g. Detector Control Systems, Detector Safety Systems, Gas Control, etc.) and the accelerators (e.g. Cryogenics, Machine Protection, Vacuum, etc.). The result was a big gain in manpower and a high homogenization across systems.

Building on this success, an effort was started in 2009 to use the same tools for the CERN infrastructure systems. These systems cover areas like Cooling and Ventilation, Electrical Distribution or Radiation Monitoring. There is now a large number of them that have benefited from this standardization effort, and there is an ongoing process to converge to the same technologies for most of the applications, if not all. The homogenization that results from this convergence process, opens the door to further integration at the SCADA layer and better operations efficiency. This paper shows the first initiative to build a hypervisor system on top of the existing applications across several domains for this purpose.

OPERATION OF THE CERN TECHNICAL INFRASTRUCTURE

Operators on shift in the CERN Control Center (CCC) are in charge of monitoring the Technical Infrastructure (TI) 24 hours a day, 365 days per year. Their duties are to detect problems, make first diagnostics and decide on actions to take. The TI encompasses the entire CERN electrical distribution network from 400 kV down to 48 V, the CV installations for all accelerators, detectors and other important facilities such as the computer centre and other systems (controlled access, safety monitoring systems, etc.). Anomalies are detected through a centralised alarm display, LASER [4], to which all systems across CERN are connected. Diagnostics are made using the application specific supervision systems.

There are more than 100 standalone CV systems around the CERN sites and their corresponding supervision systems have been developed over time with different technologies and by different people. This makes difficult for the operators to treat each non conformity as there is no standard way to establish a correlation between an alarm reported in the LASER console and the corresponding synoptic view of the process experiencing the problem. This requires that the operators have a very detailed knowledge of the various systems and makes the learning curve for newcomers very steep. Moreover, each of these applications requires individual login making daily life very tedious for the operators.

TI PORTAL

Main Requirements

TIP shall centralize the access to all WinCC OA applications deployed for the CERN TI simplifying the work of the operators in the control room. TIP must provide access to all synoptic views and trend plots available in every remote application, and must use the access control schemas locally defined in each of these applications:

- a single log-in shall be sufficient to grant the operator access to every single remote application,
- the operation can be performed by both the equipment group expert and the central operators with privilege associated to their level of expertise,
- the data shall be presented to the operators and experts in exactly the same way,

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- the auditing functionality shall differentiate if the actions on the equipment were initiated by the equipment team or by the TI operators.

As the operation in the control room is driven by critical or summary events presented to the operators through the LASER console, TIP must grant access to every single alarm generated by the remote systems, it must also differentiate unambiguously LASER alarms from detailed process alarms.

TIP shall not disturb the remote systems and minimize the impact on their performance. Additionally, it must integrate the remote systems as they are, i.e. no changes to the remote applications shall be required to connect them to TIP.

It shall be possible to reconfigure dynamically TIP to cope with changes done in remote applications: the migration of many controls applications (e.g. CV) is a continuous process that will span over many years. At any moment, old applications can be ported to WinCC OA and enter production. Moreover, due to the fast pace evolution of some systems, like the CERN electrical network, control applications may be reconfigured at any time. TIP shall be able to adapt to these changes with minimal effort, i.e. TIP must be able to discover new applications, to detect the changes in existing ones and to configure the hooks necessary to handle the new setup centrally. Moreover, the re-configuration of TIP shall be as transparent as possible to maximize the availably of the application since it is required 24/7.

The portal application shall also allow TI operators to create their own views and combined trends where they combine data from different sources to display dependencies between systems.

TIP shall also provide means to easily integrate data published by non-WinCC OA sources as the data required for operation are gathered using different technologies.

Architecture

Figure 1 presents the architecture of TIP, the connections with other systems, the different kind of operators and illustrates its central role in integrating data from various sources. TIP is part of a distributed WinCC OA application. This native feature of the SCADA allows access from TIP to all data from the remote systems and offers seamless display of views without any extra effort. Other systems can be added to and removed from this distributed network at any time giving flexibility and future-proof design.

TIP is built using the same control frameworks and share the same GUI principles as the remote applications giving a familiar environment to the operators and drastically shortening learning curve.

TIP makes usage of a local file repository which is periodically synchronized with the file systems of the remote applications such that TIP always has an up-to-date copy of the scripting libraries and user interface files.

Another important feature is the possibility to access historical measurement data. This is achieved by connecting TIP to the central ORACLE database used by the applications.

CERN network database (LANDB), is also used by TIP to provide detailed information about devices, like displaying the geographical location of the PLCs in the CERN facilities.

Finally, the Alarm Help application is used by the TI operators to display very detailed information about LASER alarms like intervention procedures, list of affected devices, consequences, etc. TIP interacts with this application bi-directionally to provide navigation from the LASER alarm to the remote WinCC OA synoptic view of the process and vice-versa.

User Interface

It is necessary to acknowledge that many of the features of TIP presented here are inherited from the underlying frameworks and the distributed nature of WinCC OA which greatly decreased effort needed to develop the application. Figure 2 shows an example screenshot from TIP main user interface. The top area is occupied by the TIP Global Toolbar, which enables access to general functions of the application i.e overall alert screen that shows alarms from every single connected WinCC OA system.

The information in TIP is organized into different views. For example, in Figure 2, the CV process information such as status of pumps, flows, pressures, etc. are shown in the first tab, whereas the status of the readout systems, PLCs, data-servers, WinCC OA projects, are shown in the infrastructure tab. TIP features multiple points of view targeted to different users, in order to provides a window to a subset of the information handled by the application.

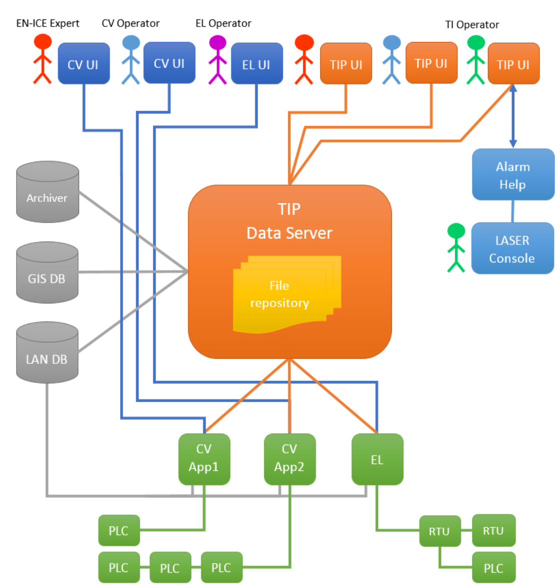

Figure 1: TIP architecture and context.

The information is organized in a tree-like structure where leave nodes in the tree represent a set of LASER alarms and the systems applications (here CV) whereas top level nodes group them geographically. Each node in

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this tree used colours that represent the presence of active LASER alarms. The colour of the nodes is propagated all the way up enabling operators to easily localize active alarms by expanding the tree. Selecting a node in the tree causes the main area of TIP to be updated with the synoptic view associated to the node.

Figure 3 and 4 show examples of graphical interfaces, which are displayed as the operator navigates in the tree. Figure 3 shows the main operational parameters of the LHC CV systems. TIP makes usage of modern visualization techniques like spiderweb graphs and the Javascript visualization package Highcharts [5] whenever applicable to enrich the user experience. This was achieved by extending the WinCC OA HMI functionality to integrate web technologies as presented in [6].

Figure 4, shows some of the main parameters involved in the safety of the Point 1 of LHC. These user interfaces merge information from the electrical network, elevators, the LHC access control system, and the status of the Oxygen Deficiency Monitors.

GIS Integration

The TIP GIS Module combines geographical data with LASER alarm location information. The buildings shown in the map are also coloured according to the presence of active LASER alarms. This provides operators with very valuable information on the location of the problem that helps in the discussions with the intervention teams. Navigation is also possible using the GIS Module. By clicking on a red or green location it will cause the module to zoom on this area and display applications that are present in this particular location. The operator selection of a node in the impact tree also causes the GIS Module to be updated by zooming on the area where application, or group of applications, is located.

LASER Integration

The LASER Alarm Info box shows detailed information about the alarm like its description, unique identifier for equipment, localization and responsible.

Although TIP focusses on LASER alarms, using the Remote Application Toolbar, operators can interact directly with the remote application and access its Alarm Screen, pre-configured trends or check the PLC statuses.

Challenges Faced

All applications developed by EN-ICE are using common building blocks: WinCC OA as SCADA system and the JCOP and UNICOS frameworks. Moreover, within a particular application domain, e.g. CV, all applications are largely similar and homogeneous. However, fundamental differences may exist between domain, e.g. between CV and EL. In such cases, applications may implement different device and alarm models, together with distinct access control schemas.

Furthermore, the mapping between devices, alarms and associated synoptic views may also differ depending on the application domain. To ease the creation of similar portal applications, a central database containing these metadata would be desirable. Therefore an effort is required to improve the coherency across application domains.

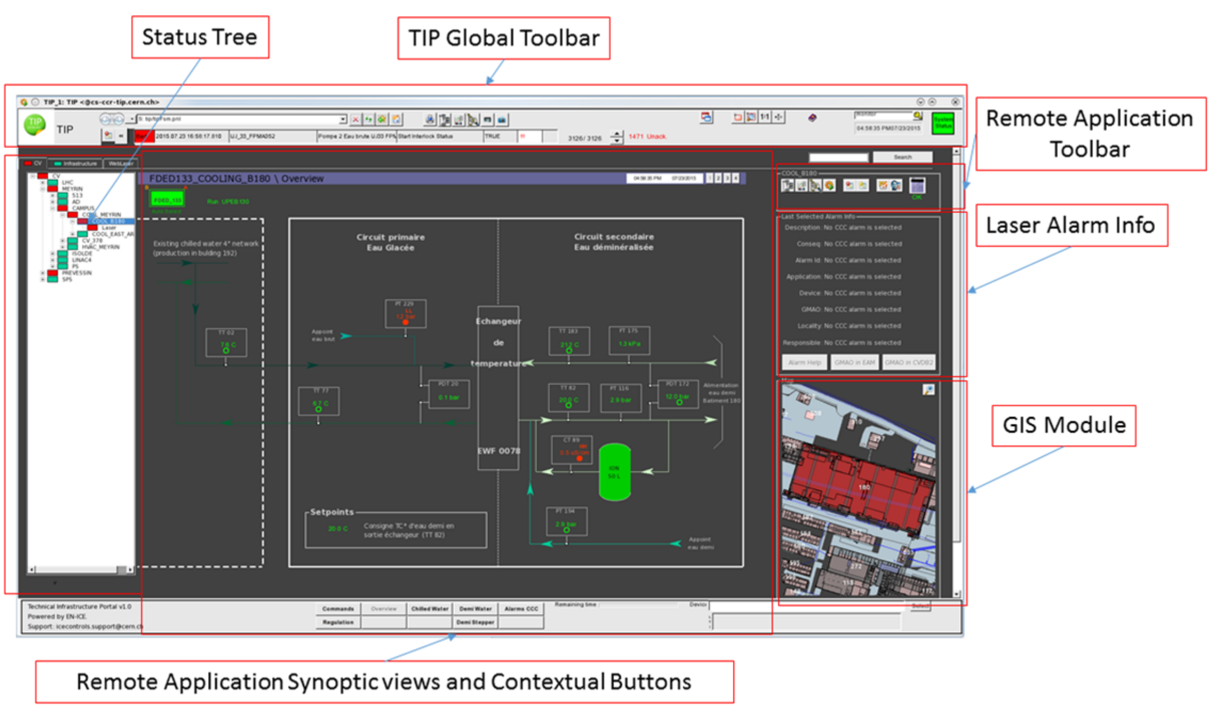

Figure 2: Main user interface of TIP.

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During the implementation of TIP, it was also necessary to extend the functionality of existing tools to be able to work on large distributed systems. These enhancements will now be integrated in the core functionality of the package.

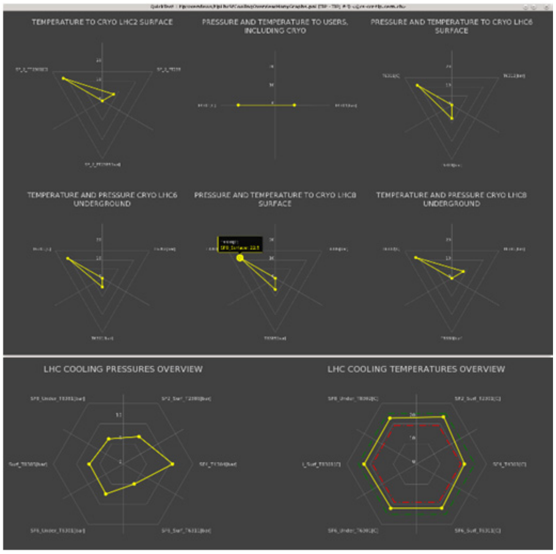

Figure 3: TIP Dashboard example.

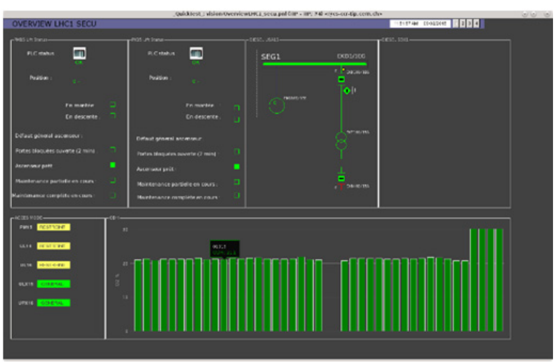

Figure 4: Compound User Interface of TIP showing information from multiple safety systems of the LHC.

STATUS AND OUTLOOK

TIP entered production in Summer 2015 and despite of the short time in use, it has already proven to be a significant improvement for the operators of the CERN TI and also for the equipment groups and the EN-ICE experts. Table 1 summarizes at the time of writing this paper, the applications that have been integrated in TIP and the number of synoptic views that can currently be accessed from TIP.

In the coming months we plan to extend the TIP to cover new domains (Radiation Monitoring system,...), and to show dependencies across different domains. In addition, TIP will be used to speed up the integration of all CERN CV systems including the legacy ones into a single tool. This is motivated by the need to provide a unique operation solution despite the long timespan of the migration process that is expected to be finished in 2025. Hence, the set of non-WinCC OA data accessed by TIP will be significantly enlarged.

Table 1: Applications under the Umbrella of TIP

Application Domain	Controls applications	Synoptic views	LASER alarms
Cooling & Ventilation	137	1846	1364
Electricity	1	211	13719
Lifts	5	0	0
Monitoring	1	335	0

To conclude, this promising start for the CERN TI, has awaken the interest of developing similar umbrella applications for many other domains like the LHC Cryogenics or Power and Interlock systems.

ACKNOWLEDGMENT

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