TECHNICAL INFRASTRUCTURE MONITORING AT CERN

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Abstract

The Technical Infrastructure Monitoring system (TIM) is used to monitor and control CERN's technical services from the CERN Control Centre (CCC). The system's primary function is to provide CCC operators with reliable real-time information about the state of the laboratory's extensive and widely distributed technical infrastructure. TIM is also used to monitor all general services required for the operation of CERN's accelerator complex and the experiments. A flexible data acquisition mechanism allows TIM to interface with a wide range of technically diverse installations, using industry standard protocols wherever possible and custom designed solutions where needed. The complexity of the data processing logic, including persistence, logging, alarm handling, command execution and the evaluation of data-driven business rules is encapsulated in the system's business layer. Users benefit from a suite of advanced graphical applications adapted to operations (synoptic views, alarm consoles, data analysis tools etc.), system maintenance and support. Complementary tools for configuration data management and historical data analysis will be available before the start-up of the LHC in 2007.

INTRODUCTION

The Technical Infrastructure Monitoring (TIM) project was launched in 1999 in order to replace the Technical Data Server (TDS). This system had reached its limit in terms of data processing capacity and was therefore unable to cope with the extensive monitoring needs of the upcoming LHC era. Furthermore, the HP based hardware platform for TDS was rapidly becoming obsolete, making it critical to replace the system with a new, state-of-the-art monitoring solution before LHC start-up.

During an extensive evaluation phase different commercial SCADA products (PVSS, PCvue) were compared with a custom built solution based on Java 2 Enterprise Edition (J2EE) technology. After detailed analysis of the results, the J2EE option was chosen as an implementation solution for TIM. The reasons for this choice were presented at the EPAC 2004 conference [1].

In July 2005, after two years of development, the first operational version of TIM was deployed in the Meyrin Control Room (MCR). This paper gives an overview of the system's functionality and architecture and reports on the experience gained after one year of operation.

SYSTEM OVERVIEW

Scope

The core function of TIM is to acquire and process real-time monitoring information collected from CERN's technical services. This includes data from the electrical power distribution network, cooling and ventilation systems and other essential services required for the general operation of the CERN sites. Data gathered by the system is presented to operators in the CERN Control Centre (CCC), equipment specialists and maintenance personnel via dedicated graphical applications and alarm consoles.

The TIM system has to be available 24 hours a day, 365 days a year, in order to ensure round-the-clock operation of the technical services. Reliable technical infrastructure operation is an essential condition for the successful exploitation of the CERN accelerators and experiments.

Architecture

TIM is a distributed J2EE application deployed in three tiers:

The *data acquisition (DAQ) tier* consists of more than 100 data acquisition modules. These stand-alone Java processes implement the communication interfaces between TIM and the various types of monitored systems and equipment (PLCs, SCADA systems, etc.). DAQ processes collect data from the supervised installations and propagate all significant changes to the business tier. They also take care of command execution and inter-process connection monitoring.

The *business tier* implements the system's business logic. It processes the data received from the DAQs and distributes it to the clients. Data processing functionality includes data persistence and logging, alarm handling, the computation of composite states as well as system supervision tasks. The business tier also manages user authentication, command execution and access to historical data.

The *client tier* consists of a suite of graphical tools for visualising the monitoring data acquired by TIM. The main client application is the TIM Viewer, a Java application for displaying animated synoptic diagrams and for performing historical data analysis. The TIM Viewer also allows authorised users to interact with the monitored installations via control commands.

The tiers are logically and physically separated and communicate with each via a protocol based on a Java Message Service (JMS) middleware. A clean separation of the layers has proven to be very valuable as it limits the dependencies between the different components and facilitates maintenance.

TIM has interfaces with the LHC Alarm Service ([2]) for displaying fault state information on alarm consoles and with the LHC Logging System for long-term archival of historical data.

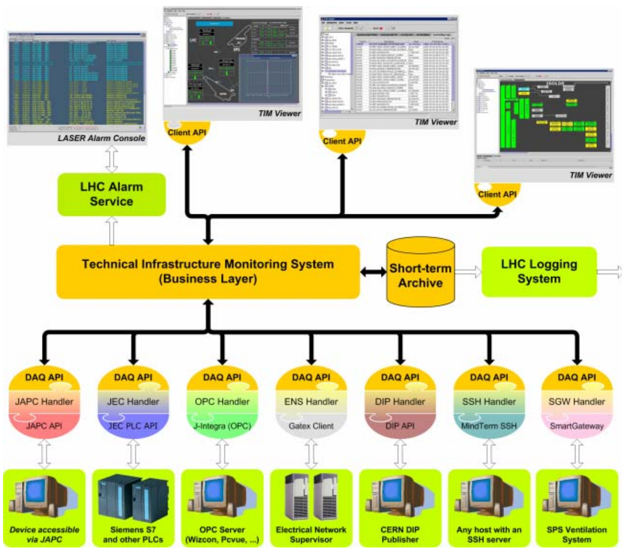

Figure 1: Overview of the TIM system architecture

For a more detailed description of the system architecture as well as the software and hardware platform for TIM, refer to [1].

TIM in Numbers

The TIM system currently handles more than 25,000 input signals, comprising 22,800 equipment states and 2,200 digitised analogue measurements. These signals are acquired from a variety of SCADA systems, PLCs and custom-built software systems via more than 100 DAQ processes. In addition, TIM handles 900 digital and analogue commands.

There are ~19,000 equipment state alarms defined in the system database for reporting abnormal situations and problems with the technical infrastructure to the LHC Alarm Service. The values of 700 analogue measurements are regularly transmitted to the LHC Logging System for long-term storage. Finally, 400 business rules are defined for computing higher-level status information (composite states) for the *Gestion Technique de Pannes Majeures* (GTPM) application [3].

In a normal production state, TIM processes on average 1.3 million value changes per 24-hour period.

TIM regularly has ~100 users connected to the system at any given instant using the TIM Viewer. On average, 10 instances of the application are concurrently running.

With the number of clients growing rapidly and new systems being connected to TIM every month, we expect the number of inputs to double over the next 5 years. The number of DAQ processes is expected to rise by 50%. The scalable design of the TIM system will allow us to increase the data processing capacity of TIM beyond these limits if necessary.

PUTTING TIM IN PRODUCTION

A first operational version of TIM was put in production in July, 2005. The migration from the old monitoring system to TIM required careful preparation and meticulous planning as the Technical Infrastructure operators needed a fully functional monitoring system at all times. The migration of almost one hundred data sources used by TIM could not be done in a simple switch-over. To solve this problem, a data bridge was put in place permitting TIM to acquire data via the TDS. Implementing such a bridge made it possible to deploy the TIM business tier and the client applications before actually changing the data acquisition mechanism. The data acquisition processes were subsequently migrated and commissioned one-by-one in a joint effort by the equipment specialists, control room operators and TIM developers. TIM and TDS were running in parallel for about three months, in order to fully validate the new system and to give the TI operators confidence in the new software before actually dismantling the old system.

USER SUPPORT AND DOCUMENTATION

Putting in place an efficient support structure was vital for a successful system launch and this structure continues to be a key element for smooth operation. A 24-hour on-call support rota ensures that qualified system experts are available at any time to deal with emergencies as soon as they arise. The emergency support hotline is only accessible to the TI operations team. It is complemented by an email support system for less critical problems that do not require immediate intervention. Email support is available to all TIM users and managed using the Problem Reporting Management System (PRMS) *Remedy* provided by CERN's IT department [4]. Swiftly resolving problems as they are reported and reacting to feature requests in a responsive manner has gained the users' trust in the system and its support structure. Keeping track of frequently recurring problems in a PRMS also allowed the support team to build up a knowledge base and to considerably improve end-user documentation. In turn, better documentation has decreased the call-out frequency from roughly one intervention per week in the beginning to one call-out outside working hours per month.

CCC Move – A Challenge for Availability

The construction of the new CERN Control Centre with its adjacent computing centre was finished at the beginning of 2006. Before the TI operators moved into the CCC, the TIM server infrastructure had to be moved from its temporary location on the CERN Meyrin site to the Prévessin site several kilometres away. This move put the redundant system architecture to a test as downtime was to be kept as low as reasonably possible. It was decided to relocate the system in two phases. The standby servers were first moved and reinstalled at the new location whilst the primary servers were kept running. Once the standby system was operational in its new location in the CCC, the remaining servers were moved. In the end, TIM downtime was limited to two 15 minute periods.

DATA INTEGRATION, CONFIGURATION AND MAINTENANCE

The reliability of monitoring information provided by TIM directly depends on the integrity of the system's configuration data. Erroneous configuration parameters can lead to incorrect monitoring data, false alarms or even partial system failures. Any configuration changes on the operational system are therefore sensitive operations. In order to minimise the risk of applying faulty configurations to the on-line system, all configuration data for TIM is managed in an off-line reference database and only applied to the online system after thorough validation.

To cope with the rapidly growing number of clients, and the frequent requests for data integration, the Monitoring Data Entry System for Technical Infrastructure (MoDESTI) was introduced in January 2006. The primary goal of MoDESTI is to manage the data declaration process, with the objective of improving overall data quality. In the first step, equipment specialists declare the new monitoring sources to be added, changed or removed using a predefined Excel form. Before the data is integrated into the reference database, it has to pass series of checks, including manual verifications by specialised operators and automatic consistency checks on the database level. Once validated and accepted, the new data configuration is applied to the on-line TIM system using automatic loading tools. All new installations are tested by TI operators and the equipment owners before they are declared operational. At each stage of this process, an automatic notification system informs the appropriate specialist about actions to be taken and problems to be resolved.

To minimise the risk of the human error during data integration, a new version of the reference database with extended validation functionalities is currently being developed. More flexible configuration procedures will also allow incremental updates and the automatic synchronisation of the on-line monitoring system with the reference database.

COLLABORATION WITH CLIENTS

The main clients of TIM are the TI operators. They have extensive experience in the use of supervisory systems in a control room environment and good knowledge of the controlled processes. Their active participation in the definition of the user requirements for TIM was therefore essential and greatly contributed to the eventual success of the project. The operators were also directly involved in the design of the synoptic views and gave significant input to the definition of the graphical interface for the TIM Viewer.

A close collaboration between the development team and the user community was mandatory to achieve the target of system deployment in the summer of 2005.

Today, all support interventions and maintenance operations on the system are planned together with the operators. The most critical system interventions are processed directly from the CCC.

Clients are encouraged to share their operational experience with the development team. Since last summer already three new versions of the TIM system have been released. Numerous system enhancements and features were developed, most of them as a result of the users' remarks and suggestions.

CONCLUSION

TIM has become the main monitoring tool and alarm gateway for CERN's technical services and has successfully replaced the previous monitoring system. A smooth transition between the two systems was achieved through close collaboration with the TI operators and the equipment groups. Experience from one year of operation has shown that TIM has succeeded in having a high level of availability, 99.5%, and has fulfilled its remit of providing a reliable monitoring system. User feedback from the TI operations team has been very positive and as a result, other users have come forward and are now considering using TIM as their monitoring solution. The access system for the PS complex was already migrated to TIM. It will be followed by the complete software layer for the access control system of the PS and SPS experimental zones. In addition, the SNIFFER system [5] as well as the LHC Access Control and Access Safety systems [6] will use TIM as an alarm gateway to the CCC.

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