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TIM (TECHNICAL INFRASTRUCTURE MONITORING) AND CCC

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Abstract

The Technical Infrastructure Monitoring project (TIM) will implement the future control system for the TCR. The aim of the project is to replace the current TCR monitoring system with a modern system built on standard hardware and software components, taking advantage of existing services and license agreements. The TIM system will be put in operation in the TCR towards the end of 2004, but is already prepared to integrate the CERN Control Centre (CCC). This paper discusses hardware, software and availability aspects of TIM and gives details as for its integration in the CCC. In particular, similarities and differences with the accelerator and cryogenics controls are considered.

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1 INTRODUCTION

The goal of the Technical Infrastructure Monitoring project is to replace the current TCR control system, the Technical Data Server, with a modern control system, based on CERN standard components and able to manage the increase in the number of monitored states related to the LHC.

The current Technical Data Server (TDS) is based on HP RISC processors, the operating system HPUX 10.20 and the message-oriented middleware product *SmartSockets*. These products are reaching the end of their life-cycle in terms of CERN support. Therefore, a decision was taken to replace them with a control system built on Intel® processors, the Linux operating system and the standardized Java Message Service (JMS).

This paper describes the selected architecture and explains the motivation behind the choices made. It also discusses the future integration of the control system in the Common Control Centre, CCC and details commonalities and differences with other control systems present in the future control room.

2 MOTIVATION FOR A COMPONENT BASED CONTROL SYSTEM

Component based applications are very flexible and have no real restrictions in terms of feasibility of applications. Solutions built on components use industry standard interfaces, and extensions or replacements of components are easily done. SCADA systems propose an integrated set of features, but are not as flexible as component ware. A SCADA system is a software package that integrates different components such as the system and data configuration, equipment drivers and data transmission to the operator user interfaces in one product.

SCADA products are adapted to homogeneous environments where the entire data chain is centrally managed, whereas the TIM project seeks to integrate data from very different sources, some of which are legacy systems and other future systems that are not yet defined. For this reason, TIM needs an information system with an open architecture allowing integration of all current and future data sources, standard interfaces facilitating the integration of common tools such as the LHC alarm and logging systems, a modular/scalable design allowing the system to evolve and grow while ensuring availability and maintainability.

3 TIM SYSTEM ARCHITECTURE

The system is intended for the monitoring and control of the technical infrastructure under the responsibility of the TS department. A team located in the Technical Control Room (TCR) today and in the CERN Control Centre (CCC) from 2006 onwards will use the TIM 24 hours per day and 365 days per year. In particular, the system has to provide applications designed for the fast start-up of the entire accelerator chain after a breakdown (GTPM). These applications integrate data from the technical infrastructure and all CERN accelerators in a single user interface. The fact that the control system will be moved and integrated into the CERN Control Centre, CCC has an impact on the design of the system in terms of:

- Hardware: common CCC system administration support is required to minimize cost and compact hardware components to minimize space requirements in the computer rooms.
- Software components: a limited number of different components and a privilege for components already existing at CERN. The choice of the operating system of the operators console will determine whether all applications can run on all consoles in the CCC or whether system specific consoles will need to be configured.
- Applications: user interfaces developed for TIM must smoothly integrate with other software developed for the CCC. A common user interface convention, based on existing conventions like the ST and the UNICOS conventions [1,2] will be issued by the SCADA Application Support Group (SASG), mandated by the controls board to elaborate a set of common standards for CERN control user interfaces.

3.1 Software Architecture

3.1.1 Multi-tier Model

Software components for control systems can be classified in four main layers or tiers: *data configuration*, *data acquisition, data transmission* and *operator console.* This standard architectural model is known as the multi-tier model.

The *data configuration* layer covers the storage of the definition (static description) of every element of the monitoring system and monitored environment in a secure and accessible location. It serves to maintain this data coherent with the ever-changing environment, and to distribute this data to the various components of the control system in order to configure them for operation.

The *data acquisition* layer consists of specific drivers connected to hardware ranging from PLC's to CERN developed special equipment and local process control systems.

The *data transmission* layer is used to transport data from equipment to monitoring applications, usually over a *TCP/IP* network. Modern systems use message brokers to transport data between remote hosts. Such systems are known as *Message Oriented Middleware* systems (*MOM)*.

The *operator console* is usually located in a control room with three main types of applications:

- *Alarm lists*, alerting operators on fault conditions as they appear, see chapter 4.1
- *Synoptic displays* (also known as mimic diagrams) showing dynamic process data in a schematic form, see chapter 4.2
- *Data logging* for trending or post mortem analysis in the form of histograms based on archived data, see chapter 4.3

3.1.2 TIM Implementation

Figure 1**Error! Reference source not found.** describes the TIM implementation and shows a *client* tier at the top containing the different user interfaces to TIM. Alarms generated by TIM will be sent to the central alarm system LASER (see chapter 4.1) for display and archiving, mimic diagrams are displayed on dedicated *JViews* panels and archiving is done to the joint LHC/TCR logging database for display with a common trend tool.

The *server* tier in the middle is responsible for the transmission of data from data acquisition modules to the different clients. The architecture chosen for the server tier is Java 2 Enterprise Edition (J2EE) including message brokers and an application server. The application server will hold all current values of measurements and states and it will indicate whether the data is to be trusted or not. Should, for any reason, parts of the data acquisition become unavailable, the server tier will indicate that the corresponding data is invalid. This will allow clients to trust the displayed data because any unavailable data will be marked as such.

The bottom part of the picture Figure 1 shows the data acquisition tier. It contains the device drivers needed to communicate with different equipment types. These device drivers have one common interface to communicate with the business tier and one specific interface to communicate with the equipment. TIM will initially propose a dedicated PLC driver and the necessary SCADA drivers, as well as an interface to the CERN Data Interchange Protocol (DIP).

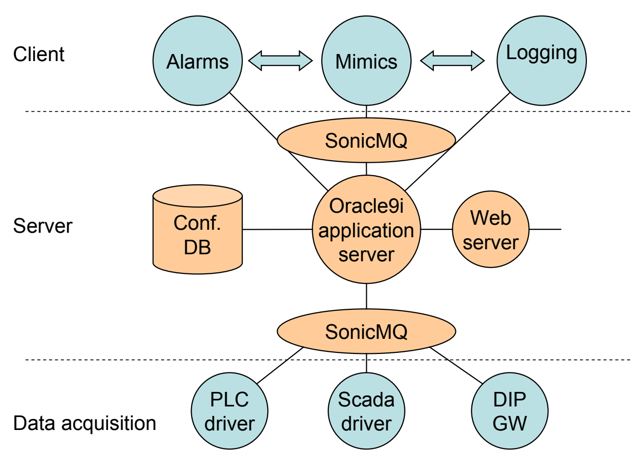

Figure 1: TIM software architecture

In Table 1 the components of the TIM system are compared with the three other main control systems that will be used in the CCC: accelerator controls, cryogenics and vacuum. TIM will use identical components and services as the accelerator controls. However, proper integration with the cryogenics, the vacuum and some other systems has to be achieved.

Table 1 Component comparison between TIM and other CCC systems

	TIM	Accelerator Controls	Cryogenics	Vacuum
Server hardware	HP ProLiant	HP ProLiant	HP ProLiant	PCshop server
Server software	OC4J/SonicMQ	OC4J/SonicMQ	PVSS	PVSS
Mimics diagrams	JViews	JViews + own	PVSS	PVSS
Alarm lists	LASER	LASER	PVSS, LASER	PVSS, LASER
Data logging	LHC/TCR	LHC/TCR	PVSS,LHC/TCR	PVSS,LHC/TCR

3.2 Hardware Architecture

A choice has been made to deploy the TIM system exclusively on CERN recommended hardware:

- Oracle database servers run on Sun Solaris systems and benefit from CERN support through IT/DB services with a written agreement.
- The data acquisition and the business tiers are hosted on HP ProLiant linux servers administered and supported by AB services.
- The client tier is running on Windows operator consoles[1], in order to run TIM native applications, ENS, Wizweb, PVSS for vacuum and cryogenics, network supervision with spectrum, LASER, D7i (MP5 replacement) and various other tools. Central support for these consoles still needs to be set-up and agreed on either with AB/CO or with IT.

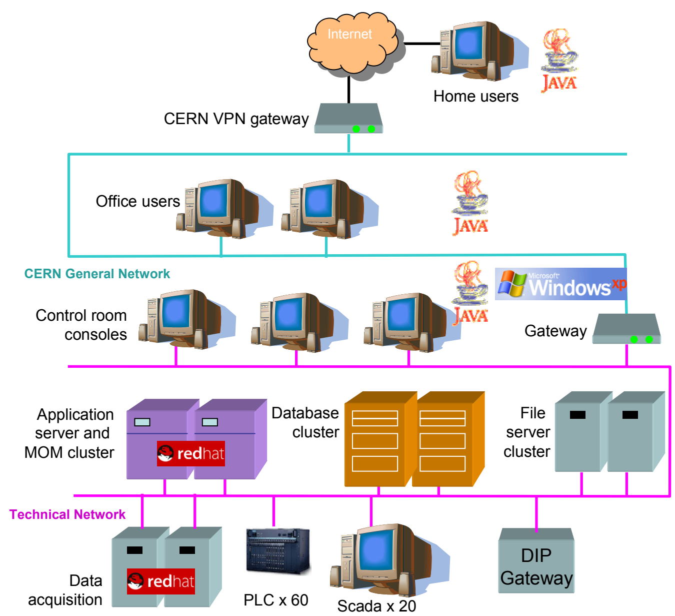

Figure 2: TIM hardware architecture

Data acquisition and *business* tier hardware is redundant. Three data acquisition hosts are available to run the device drivers. Should a data acquisition host fail, its load will automatically be

[1] The choice of operating system for CCC operator consoles is still open

taken over by the remaining hosts. The *business* tier is clustered on several separate hosts. These hosts work in parallel and share the load during normal operation and work as hot-spare failover in case of failure. TIM is also using a clustered database that delivers transparent failover and therefore high availability.

All hosts and file servers are equipped with RAID disks providing high availability and tolerance to disk failures. Warm spare file servers are available to be put in service, should the main server fail. In addition, each host is equipped with dual power supplies, one connected to the normal network and the other to the secured network.

Hardware is mounted in two separate racks. One will be located in the CCC computer room while the other may remain in the existing TCR computer room. In addition to this physical separation, the common modes for the network and the electricity supply need to be eliminated which is not the case today. TIM hardware will exclusively use the *Technical Network*. Connecting redundant hosts to separate switches makes the system resilient to network failure.

3.3 System availability

The redundant or clustered hardware set-up will guarantee optimal availability. The constraints are defined according to the Safety Integrated Level (SIL) 1 to obtain a better than 99% system availability. In addition, the SIL 1 implies constraints for development, maintenance and configuration of the system and suggests techniques and measures for control of failures during operation [3].

3.4 Data integration

TIM will integrate internal data coming from existing PLC's and SCADA systems already integrated in today's TCR monitoring system directly via the data acquisition layer. External data coming from systems such as accelerator components, vacuum and cryogenics systems will only be acquired via DIP.

4 CLIENT TIER

4.1 Alarm Lists

The TIM project aims for a common alarm display to be used by all operators in the CCC and other control rooms at CERN avoiding additional resources of creating a proprietary alarm interface. The common display will be the LASER system developed by AB/CO as the successor to the Central Alarm System (CAS). The TCR will use the LASER product as its main alarm screen. By doing so, the TCR will have access to any alarm through a single user interface, whether the alarm is generated by the TIM system or by a dedicated equipment control system like the cryogenics. Today approximately 15000 alarms are defined in the TCR. This number will increase in the future, as equipment will be supervised by using more detailed information.

4.2 Synoptic Displays

There are today 32 process applications totaling some 700 mimic diagrams. The diagrams mainly concern the three domains electricity, safety and cooling & ventilation. These domains are currently implementing local control systems in the form of SCADA systems:

- The Electrical Network Supervisor (ENS) for electrical equipment,
- PcVue for safety equipment (e.g. CSAM project) and
- Wizcon for cooling and ventilation.

These SCADA systems all offer remote access to their proprietary mimic diagrams. A decision has been made not to duplicate these diagrams, but implement in TIM the mimics that the SCADA systems do not provide for operation and access native SCADA diagrams through appropriate navigation. An example is overview mimic diagrams or GTPM views displaying data from different systems in a single application or detailed views for equipment not monitored by a SCADA. All the mimic diagrams not integrated in a SCADA will be ported to the TIM system.

In the CCC, operators will probably work on different accelerators and services (cryogenics, technical infrastructure) even during a single shift. Therefore it is essential that the mimic diagrams and other operator tools have the same look and feel. This concerns in particular colours, symbols, screen layout and navigation. SASG has the mandate to produce a CERN wide standard. Parallel initiatives like the AB/OP "White Book" might lead to two different standards, whereas it would be necessary that all operation teams produce a single set of requirements for CCC software applications.

4.3 Data Logging

The data logging trending functionality is divided in two parts; data acquisition and data display. The LHC Controls Project, LHC-CP is setting up a new data logging facility both for logging data to a database and retrieving data in a user interface. The TIM project will use identical facilities to allow cross-system correlation possibilities and to reduce the development costs for the logging system. Today around 850 analogue measurements are logged. This number will increase with the integration of LHC systems.

5 PROJECT STATUS & PLANNING

The TIM system must be in production by the end of 2004, when the official support for the HPUX operating system used for the TDS ends. By December 2004, all existing TDS data must be transferred to TIM and the necessary data clients must be ported to the new technology.

After a specification and feasibility phase, and a system installation phase including purchasing and setup of the new infrastructure, the project is now in its design and implementation phase. The deliverables will be deployed in a number of iterations, starting with the core system and a gateway importing data from the TDS, followed by a migration of user interfaces and data acquisition modules, gradually completing the functionality until December 2004 when the TDS system will be switched off.

Although delays in hardware installation have deferred the delivery date for the first iterations, the initial plan to deploy the pilot TIM application by mid 2004 is still valid. The purchasing phase is terminated and the project will be delivered with a total cost slightly lower than planned.

6 CONCLUSION

The TIM project is well on track to replace the existing TCR monitoring system by the end of the year 2004. The integration in the CCC adds some additional constraints that can easily be handled from a technical point of view. However, for the technical services operation in the CCC TIM, the accelerator, cryogenics and vacuum controls have to be integrated, in a single platform as well as the safety monitoring systems CASM, RAMSES and LACS. This has an impact on the choice of the operating system in the operators console as well as on the design of the mimic diagrams. Decisions that affect all the control systems used in the CCC will have to be made with all controls groups concerned. Today, existing co-ordination structures for controls are not used in this respect. As far as the mimic diagrams are concerned, a single standard for all CCC applications needs to be defined. Work on this subject shall be re-organized to make this happen.

7 REFERENCES

[1] ST user interface conventions, P. Sollander 2003, EDMS 366286

[2] Human Machine Interface for Unicos in PVSS applications, P. Gayet 2003

[3] Functional safety of electrical/electronic/programmable electronic safety-related systems, IEC-61508-2