SCADA FOR TECHNICAL INFRASTRUCTURE MONITORING

U. Epting, P. Sollander, R. Martini, R. Bartolome, F. Havart, J. Stowisek

Abstract

Supervisory Control and Data Acquisition (SCADA) systems are widely used at CERN and in industrial control environments. Recently the CERN Controls Board recommended a SCADA system for use in the CERN experiments and the controls sectors. The Technical Control Room (TCR) currently monitors the complete technical infrastructure at CERN using a component-ware architecture. A migration to the recommended SCADA system has been started in order to be ready for the monitoring of the future LHC infrastructure. This gives the advantage of having an integrated tool for alarms, mimic diagrams, trending and data acquisition but requires a careful analysis of the hard- and software architecture. The configuration management, the supervision of the different elements in the control chain and the data exchange with other systems will play an important role and have to be considered from the beginning.
INTRODUCTION

Most of CERN’s controls applications are based on different software components, which can be classified at the three main levels: *operator console, data transmission* and *data acquisition*

The *data acquisition* layer consists mainly of specific drivers connected either directly or via field-buses to hardware. This ranges from PLCs to CERN in house solutions. The local control of the equipment is part of this layer.

The data transmission layer is used to transport data from the equipment to at least one control or monitoring application. This is usually done by remote procedure calls (RPC) or a middle-ware over a *TCP/IP* network.

The monitoring of the equipment is typically done from a control room using three main types of applications: *alarm lists, synoptic displays* (also known as mimic diagrams) and *data logging tools* for trending or post-mortem analysis

A SCADA system is a software package that integrates the different components from the equipment drivers up to the operator’s applications in one product.

Component-ware based applications are usually very flexible and have no real restrictions in terms of feasibility of applications but several system experts are required to maintain the variety of the different and often very specialised applications. SCADA systems cover most user requirements but are not as flexible as component ware. “Open” SCADA products, however, allow the development of individual functionality to cover special requirements.

Budget and staff reductions are today’s reality at CERN. The construction of the LHC however, requires sophisticated and high performance control systems. This goal can only be achieved if the different control groups work together and synergy effects are exploited. The aim is to reduce product and licensing costs, to group administrative and support activities to ease the maintenance of the systems and to obtain in-house expertise. Exchange of knowledge and people between divisions and experiments will be much easier and the time spent problem troubleshooting should be reduced.

FUNCTIONALITY

The system is intended for the use in the Technical Control Room (TCR) at CERN and has to be fully operational 24h/day and 365d/year. It will be used by operators to monitor the complete technical infrastructure at CERN and thus has to follow certain design standards in order to ease operation as much as possible. This should be achieved by using a common environment and following the TCR Human Computer Interface (HCI) conventions. The following pictures show how the functionality is distributed in a logical model:
2.1 Alarms

The Technical Infrastructure Monitoring (TIM) project aims for a common alarm display to be used by all services, such as the PCR, TCR, SCR and other control rooms. This would have the advantage of sharing a single development process and of centralizing all CERN alarms in a single tool. However, different constraints in the groups and different deadlines make it difficult to design a single tool in due time. This common alarm display, currently known as Central Alarm Server (CAS) and being developed by SL-CO, has to be considered very carefully since the technology of this implementation is not yet fixed. Therefore the following strategy is proposed:

In either case the TCR and SCR envisages the use of an alarm panel that is fully integrated in the chosen SCADA software. If necessary it will be configured to cover the TCR and SCR’s requirements. This means that a well defined interface to the CAS is needed in order to interchange any available CERN alarm. This might be either a direct SCADA to SCADA interface or a special driver implementation if the final choice of SL-CO is different from the ST-MA SCADA solution.

Today approximately 15000 alarms are defined and it is expected that this number will increase in the future because the supervised equipment will provide more detailed information than today.

2.2 Mimics

There are today 32 applications totalling some 700 mimic diagrams. It must be decided whether they should be ported to the SCADA solution or simply remain until the concerned system is obsolete. The chosen strategy is to develop new functionality directly in the SCADA and migrate existing applications to the SCADA as soon as major changes are required. A detailed migration planning for the remaining applications will be established as soon as some experience is gained in the SCADA development and time estimations can be made more precisely.

2.3 Data Logging and Trending

The trending functionality is divided in two parts; data acquisition and data display. The data acquisition is currently either done on an event basis or by polling equipment periodically with special logging processes. In both cases the acquired data is written to an external Oracle logging database. Data display is performed by the "JavaGUILS" client, a tool produced and used by both ST and SL division.

Future trending with the SCADA solution must deliver the same functionality, i.e. data acquisition, storage and display. The SCADA system has an internal archiving function that allows logging to an internal database and display with predefined and integrated tools. Predefined datapoints can then be exported to an external Oracle database and be used by the CERN community, e.g. TIS or other control rooms for post-mortem analysis. Some of the datapoints have legal archiving constraints and therefore require a very robust data logging strategy. The SCADA trending tool will also be used to access external data sources, such as Oracle and thus allow access to more data than just the TCR data sources.

Today 2700 analogue measurements are logged by polling, and 500 on an event basis. This number is expected to increase in the future.

2.4 Supervision

All components in the complete chain from data acquisition up to the monitoring level need to run 24/24h. A system failure must be detected immediately in order to be able to take the appropriate actions and thus all components need to be supervised permanently. This can be achieved by using a watchdog mechanism that periodically sends “alive” messages. Every independent software component must send in (configurable) intervals an “alive” message to a supervisor module. The supervisor module will check the existence of all components and generate an alarm if one is missing.

In addition each software module should implement a callback mechanism, i.e. can show its presence and reply to a verification request immediately.
2.5 Data Transmission and Acquisition

The data transmission will be done by using CERN’s services network which is based on Ethernet and TCP/IP. The data transmission functionality as well as error handling like network unavailability, automatic recovery or transmission speed problems must be handled internally by the SCADA system.

The different data sources will be integrated by either standard drivers like OPC or PROFIBUS drivers or by special driver developments in order to cover CERN’s already existing infrastructure. It is envisaged to integrate already existing equipment in a transparent way, such that no new development will be necessary.

Data acquisition is done either by using PLCs and appropriate I/O-devices, e.g. Multipurpose Monitoring Device (MMD) or by integration of other SCADA systems using special equipment controllers (SCADA-EC). As most of these systems are not under our responsibility a very stable interface definition is required.

2.6 Configuration Data

The proposed SCADA based monitoring system is fully data driven. The correct definition and management of monitoring data is therefore of paramount importance to the overall performance of the system. It is planned that the SCADA system should be configurable from an external (Oracle) database. This solution is chosen for the following reasons:

- system independence (when the monitoring platform changes much of the underlying data does not),
- data for applications outside the core monitoring system will always be necessary, and therefore a single database of monitoring data cannot be based on one part of the monitoring system,
- the offline database has the function of “documenting” what is monitored, and therefore must have the appropriate reporting tools.

In order to achieve a successful implementation of a SCADA based monitoring system a thorough understanding of the data structures used must be obtained. Based on this, an appropriate coding/naming system is being defined and implemented. The current configuration database TDRefDB is being modified to represent these new data structures.

3 IMPLEMENTATION STRATEGY

3.1 Hardware

Standard off-the-shelf products will be used as hardware. This has the advantage of easy replacement, repairs and cost reductions. The Technical Infrastructure Monitoring (TIM) system will run on PC hardware, using Ethernet as data transmission network and will be secured by uninterruptable power supplies (UPS).

It is foreseen to use two redundant LINUX servers with secure network connections. They will be situated in the air-conditioned TCR server room (aquarium). The operator consoles will run Windows 2000 and thus include the advantage of having access to the complete CERN office infrastructure. Existing UNIX or OSF/Motif applications can be run using an Xterminal emulation software such as Exceed. It is planned to use the same number of operator consoles as today, i.e. four dedicated alarm screens plus four additional monitors. The operator consoles must be independent from each other. In case of network problems, they must be able to start-up and run in standalone mode.

The configuration and logging database is installed on a SUN server. A file server for keeping installation and application files must be installed in order to have a independent hardware solution.

The following picture shows an example of today’s system setup:

3.2 Software

Standard software packages should be used wherever possible. It is foreseen to use Redhat Linux (CERN standard version) as operating system for the servers and Windows 2000 (standard CERN configuration) for the operator consoles. PVSS II from ETM has been chosen as the CERN
recommended SCADA system (CERN standard installation). For the data acquisition and interfacing to different systems it is foreseen to develop special drivers that can be used by the CERN community. It is envisaged to keep the number of different products to the absolute minimum.

3.3 Network

The monitoring system will rely on the centralized CERN service network that is maintained by IT/CS. It has to be verified that all critical network paths are either redundant or that an uninterrupted service can be assured by the network service provider.

3.4 Installation and Configuration

A completely tested standard installation covering all system parts will be kept in a software configuration and management tool (Razor). Three independent system hardware installations are available (development, test and operation). The operational system must only be modified after a complete validation of changes on the test platform. Before putting a new configuration or installation in operation the predefined test procedures must be performed and acknowledged.

All configuration data will be kept in a Technical Data Reference Database (TDrefDB). The data will be extracted by configuration tools for the configuration of the different layers and modules of the control system. The configuration tools must always be available and a complete reconfiguration of any operational part must be possible by any trained person (i.e. piquet participants or TCR operators). It is foreseen that the reconfiguration or update of system parameters must be possible without stopping the operational system (online configuration).

The operational operating system version and all software needed to run the monitoring system should be burned on a bootable CD to assure an identical environment in case of a system restart.

3.5 Migration

The specification and implementation of the complete TIM system has to be ready for the LHC start-up in 2006 latest. However most of the components have to be used before in test environments like QRL and STRING-2 and thus have to be ready before 2006. Therefore implementation is planned in 3 phases:

- Replacement of the existing applications by PVSS panels using the TDS as data server.
- Replacement of the TDS by full data transmission via PVSS. This means, that the appropriate PVSS drivers have to be ready and the equipment can be connected directly to the PVSS system without using the TDS anymore.
- Integration of common tools like alarm screens (CAS) and trending utilities (JavaGUILS) into PVSS.

4 SUPPORT AND MAINTENANCE

The support of all levels should be organised in two layers:

- Local support by ST-MA (FreePiquet service) and the help of the C168 contract
- Common support, by IT

A local support team will handle the first line interventions and act as filter for additional support needs.

4.1 Hardware support

Hardware support should be assured by the ST desktop support and the IT helpdesk and/or PC shop. Network problems will be handled by IT/CS. First help on PLCs and other data acquisition hardware will be handled by ST-MA with the help of the C168 contract and then by the existing contracts with the hardware suppliers.

4.2 Software support
Support on standard software should be given by IT division. Depending on the system this might be the IT helpdesk (Windows, Linux, WWW, applications e.g. Exceed, etc.) or IT-CO (PVSS support).

4.3 Application support

Application dependant help will be organised in ST-MA (Free Piquet service) with the help of the C168 contract for first line intervention and help on application problems.

5 CONCLUSION

The Technical Infrastructure Monitoring (TIM) project concerns almost all domains of a control system. The use of a SCADA system to replace today’s “component ware” architecture seems to be very promising, although there is a vast area to cover and many modules to develop. The project seems to be feasible and should be completed for the LHC start-up in 2006. This assumes a stable personnel situation and organisational structure as many dependencies between the different CERN groups have been identified. Another important aspect is the financial issue. Most of the development work will be outsourced and thus the budget for the contracts has to be foreseen and committed to by the management.

6 REFERENCES

[1] TCR Human Computer Interface Conventions – P. Sollander, V. Camara, 2000
[2] LHC Controls Project web site (cern.ch/lhc-cp)
[4] Is the CERN recommended SCADA usable for the ST division – P. Sollander and al., ST workshop 2001
[8] ETM web page (http://www.etm.at/)