ALARMS CONFIGURATION MANAGEMENT

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Abstract

The LHC alarm service, LASER, is the alarm tool used by the operators for the accelerators and the technical services at CERN. To ensure that the alarms displayed are known and understood by the operators, each alarm should go through a well-defined procedure from its definition to being accepted in operation. In this paper we describe the workflow to define alarms for the technical services at CERN. We describe the different stages of the workflow like equipment definition, alarm information specification, control system configuration, test, and final acceptance in operation. We also describe the tools available to support each stage and the actors involved. Although the use of a strict workflow will limit the number of alarms that arrive to LASER and ensure that they are useful for operations, for a large complex like CERN there are still potentially many alarms displayed at one time. Therefore the LASER tool provides facilities for the operators to manage and reduce the list of alarms displayed. The most important of these facilities are described, together with other important services like automatic GSM and/or e-mail notification and alarm system monitoring.

INTRODUCTION

CERN's technical infrastructure is monitored from the CERN Control Centre (CCC). The CCC is manned 24 hours a day and 365 days per year. The control room is divided by activity in four islands. One of the islands is staffed by the technical infrastructure (TI) operators. Their mandate is to minimize the impact of technical breakdowns on accelerators and other important installations, to manage corrective maintenance activities and to co-ordinate interventions during breakdowns.

The systems supervised by the Technical Infrastructure operators range from electricity distribution, cooling, ventilation, safety systems and vacuum to control system components cryogenic equipment, lifts and heavy handling equipment. In all there are several thousands of pieces of equipment spread over the various surface and underground sites around CERN.

A failure on a piece of equipment is signalled to the operator either by phone or on an alarm screen. It is the job of the operator to analyse the information he receives and to take the appropriate actions. In 2006, the TI operators received more than 20'000 telephone calls and more than 500'000 alarms and generated over 8'000 work orders for corrective maintenance.

The operators use three main computer tools to manage their task:

- LASER alarm screens, to get alerted of an event.
- Synoptic views, to diagnose and repair
- A Computerized Maintenance Management System (CAMMS) to create and follow-up work orders.

It is of the utmost importance that an event is consistent among these tools; a fault signalled on the alarm list must also be visible on the synoptic views and the state of a work order must be visible from the alarm list to give the operator a possibility to follow-up an event.

The following sections will concentrate on alarms and explain the system architecture, the alarm configuration workflow, how the alarms are managed in a way to make them comprehensible to operators, how the alarm system is made robust and also what services are connected to alarms. Although LASER is the common alarm tool for the CERN Control Centre (CCC), this paper will concentrate on the use made for technical infrastructure. First however, it is necessary to define what is meant by an alarm in this context.

DEFINITION OF AN ALARM

The notion of alarm differs in different organizations and in different tools and applications. At CERN and in the context of control room monitoring, an alarm is defined as <u>an event that needs operator attention and action</u>. An alarm is directed towards an operator who must have a fundamental understanding of layout, processes and systems. An alarm cannot carry all information necessary for the appropriate response [1]. Understanding the alarm information relies on organization wide common conventions for elements such as equipment identity and location.

ARCHITECTURE OF THE ALARM SYSTEM

The alarm system known as LASER (LHC Alarm SERvice) is made from 5 main components on 3 tiers. These being: sources, middle tier servers, a database, message oriented middleware (MOM) brokers and operator consoles.

The MOM brokers, running as a highly available cluster, provide a communication service between all the tiers. The database also has redundant instances for storing alarm definition data as explained above.

Sources send alarm events to the middle tier and these contain an alarm identity, timestamp and state (active or terminate). Sources are software processes, created and maintained by alarm providing clients, which monitor their infrastructure or accelerator subsystems. Each one is monitored by LASER, and if any fail, then an internal alarm is raised to notify operations of this problem.

The middle tier processes incoming alarm events, does some verification such as checking that the identities are valid, then stores the event, and delivers any necessary alarm change to the consoles along with its corresponding definition.

Finally, consoles subscribe to subsets of alarms (categories), show alarms as they occur, and also provide access to the archive, and other alarm information.

LASER handles the alarm tools and event delivery, however, the quality of alarm data depends primarily on the definition process.

ALARM CONFIGURATION WORKFLOW

The Technical Infrastructure Monitoring (TIM) system [2] handles the acquisition, processing and distribution of alarms, measurements and states essential to ensure the smooth running of the accelerator complexes and their related support activities.

The Alarm definition process requires several services to work in a specific sequence starting with equipment specialists, involving TI operators and ending with TIM support. Alarm integration includes cabling to monitoring units, declaration and validation of data in a reference database, configuration of the monitoring system, definition of the actions to be taken by the operators as well as the testing and acceptance of the alarm. To work efficiently and to deal with the growing number of new alarms and frequent update requests, this complex process requires coordination.

To manage this process CERN devised the Monitoring Data Entry System for Technical Infrastructure (MoDESTI). The data defining the alarm(s) is first entered on a standardised Excel sheet and then submitted to the workflow tool based on CERN's Electronic Data Management System (EDMS) [3]. This tool allows the different people involved to act in the pre-defined order. The system generates e-mail informing the appropriate specialists about the next steps and actions to be performed or problems to be solved. Moreover, at any moment, the alarm requestor can check the status of his/her request.

Before the alarms are integrated into the system, they are both manually checked by the TI operators and submitted to automatic consistency checks. Once alarm definitions are validated and stored in the reference database, they can be safely configured in the TIM and LASER systems. The configuration of the two systems is synchronised and covers new alarms, deleted alarms, as well as changes to alarm descriptive data. All new technical infrastructure alarms are initially declared in 'test' mode and will appear on the LASER alarm screen in a distinctive way so that operators do not treat them as real alarms. Once the new alarms are tested and conform to the requestor’s needs, they are configured in 'operational' mode. At this point the MoDESTI request can be closed.

CERN has chosen to define many detailed alarms rather than few general alarms. Currently, the Laser system hosts 140’000 different alarms and the number is expected to grow to approximately 400’000 when all alarms for the LHC have been defined. The advantage of having many detailed alarms is that single faults are described in detail and can be handled more quickly and easily, giving better maintenance management. The disadvantages are: first that the alarm system must handle a high average throughput of alarms, second that each individual alarm must be described and configured, and finally operators must handle a large number of alarms simultaneously. For instance when a general power outage occurs, alarms are generated from many different systems [4].

To solve these issues, CERN has put in place a scalable architecture for the alarm system, an automated process for alarm definition and a set of different means to handle the flow of incoming alarms on the console level.

In the past few years, CERN has completely renovated its alarm system; a new data integration procedure MoDESTI based on EDMS has replaced an older system and given a more rigorous integration mechanism; the TIM control system has replaced a previous generation of infrastructure monitoring tools, improving availability, robustness and correctness issues; finally, LASER rationalized and updated the long-standing previous generation of the alarm system.

ALARM MANAGEMENT TO AVOID FLOODING SCREENS

The alarm console, combined with the server and using alarm definition parameters has several mechanisms for limiting the number of alarms on screen to a usable maximum and organising them. This is especially useful when there is a major incident such as large electrical failure.

Priority – Each alarm has a defined priority, higher priority alarms require an immediate action, lower priority alarms can wait until the following working day if necessary.

Categories – Alarms can appear in one or more categories thereby creating subsets of alarms. Consoles are configured to show alarms in categories that a particular operator is interested in.

Filters – Alarms can be filtered out based on their definition and identity. Console users can create a more focused set within a category.

Masking – Some active alarms can be masked, they will return on the main list if they are re-activated again. This is used to temporarily remove alarms that are being treated by the maintenance teams.

Inhibiting – Some alarms are waiting to be removed as their underlying hardware, or sensors have been removed. They are inhibited so they will never appear on the main list again. Some alarms exhibit annoying behaviour such as oscillation between states. They are inhibited until a specialist can solve the issue.

Reduction – Alarms can be grouped into similar problems, and often represented as a tree with a parent alarm representing a set of problems. The parent is seen on the main console list, with the ability to see the children associated with it if necessary.

Oscillation control –If an alarm repeatedly changes state due to underlying hardware or surveillance problems, this is shown as a continuous alarm in an oscillation state.

ALARM SYSTEM AVAILABILITY, CORRECTNESS

Alarm systems in general, and LASER specifically, should work "correctly" and always be "available". We consider what this means here.

In terms of "continuous availability", LASER relies on a set of other physical services such as its server machines, as well as a set of infrastructure services such as networks, and databases. It also itself is composed of components, such as the MOM brokers and sources. It is virtually impossible to guarantee that all of these can provide a continuous service under all circumstances. Having acknowledged that some of this can fail it is important to make the failure and the consequences obvious so it can not only be fixed, but also so it can be understood that unaffected parts of the system can still be used and will behave correctly. LASER was designed to be failsafe such that alarms are generated and displayed if there is any doubt. If at any time a failure could cause misunderstood behaviour, it is better for the system not to be available. The alarm consoles provide supervision of the LASER system itself by showing different icons according to the availability of the alarm server.

At some point in the life of an alarm system, a serious situation *will* occur. It is very important to focus on learning from the outcome to improve the system to reduce a reoccurrence. It would be unfortunate that only when a serious or costly failure (sometimes involving insurance, safety, or legal issues) occurs, is any lack of resources closely examined.

OTHER LASER SERVICES

LASER also provides some additional services.

History – The console can show the previous times the alarm was activated or terminated up to the last 6 months.

On-screen search – A quick search facility highlights alarms on the console with the requested text.

Archive – the alarm system stores all events for 2 years. This archive can be searched for sets of alarm events.

Alarm definition information – The global known set of definitions is available for consultation.

Alarm list export – The alarm system allows exporting all lists (active, history, search), to a printer or as email.

Diagnostics – The console can embed components that can request further information and display it directly from a subsystem. An example is *Help Alarm.*

Help Alarm (HA) is a web based GUI to display additional information about an alarm such as cause, consequence and actions for the alarm but also temporary instructions and work orders produced for the equipment. By giving the possibility for *on-line* data modifications, Help Alarm aids in keeping the alarm information up to date; an operator can easily initiate a modification directly from the GUI.

Alarm Notification System (ANS); it is possible to configure LASER with an ANS identifier so that, when an alarm is activated, the corresponding identifier is sent to the ANS. In this case, an [A] prefix on the alarm will let operators know that an automatic notification has been issued. The notification can take the form of a telephone call, an SMS, an email message or any combination of these. An acknowledgement of the reception of the automatic call is sent to the control room operator by email.

CONCLUSION

Alarm management in the heterogeneous environment of the CERN technical services is a complex and sensitive domain. Not only do the technical components such as data collection, transmission and display have to be robust and sophisticated, catering for a wide variety of situations and functions, but the definition and maintenance of the alarms has to be rigorously applied.

The renovation of the control system for LHC operation was the opportunity to implement an open architecture with the necessary improvements allowing the flexibility and scalability needed to adapt to future requirements. Alarm data quality is assured by implementing a strict workflow giving control of the alarm definition and integration process to each concerned unit and providing full traceability of modifications.

The system, in operation since 2005, has proved successful and is ready to take on the remaining data for LHC operation in 2008. However, as organizations are dynamic by nature and continuously change, there is, and will always be, room for improvement.

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