Revisiting CERN Safety System Monitoring (SSM)

CERN Safety System Monitoring (SSM) is a system for monitoring state-of-health of the various access and personnel safety systems at CERN since more than three years. SSM implements monitoring of different operating systems, network equipment, storage, and special devices like PLCs, front ends, etc. It is based on the monitoring framework Zabbix, which supports alert notifications, issue escalation, reporting, distributed management, and automatic scalability. The emphasis of SSM is on the needs of maintenance and system operation, where timely and reliable feedback directly from the systems themselves is important to quickly pinpoint immediate or creeping problems. A new application of SSM is to anticipate availability problems through predictive trending that allows to visualize and manage upcoming operational issues and infrastructure requirements. Work is underway to extend the scope of SSM to all access and safety systems managed by the access and safety team with upgrades to the monitoring methodology as well as to the visualization of results.

Access and safety systems by GS/ASE

- LCS (LHC Access Control Systems) - which extends LCS and where
- LASS (LHC Access Safety System) - it is safe to beam or access at LHC
- PACS (PS Access Control System) - it extends the PS and when
- PPS (PS Access Safety System) - it is safe to beam or access at PS
- SPS PSS - integrated personnel safety system for SPS
- SUSI (Surveillance des Sites) - who enters CERN sites and areas other than the acceleration sites

Design principles

- Clear: no reinvent approach to system monitoring. Use global status displays with simple traffic-light-style graphics.
- Simplicity: well-defined interfaces with clear functional descriptions. Use existing systems and CERN standard services when possible.
- Reliability: self-diagnostic checks to tell if the displayed information trustworthy.
- Independence: look at the system to be monitored from the outside and avoid using information produced by that system. Go to the source whenever possible (example: access PLCs directly).
- Maintenability: scripts and database structure simple with up to date documentation.
- Usability: works with all major web browsers and handheld devices from anywhere.
- Confidentiality: Access limited to a well-defined group and login with CERN password.

Architecture overview

- A master SSM/Zabbix server is connected to a local MySQL database, which stores all the monitoring data.
- Zabbix proxy servers connect to devices on the private networks of PACS, test platform of PACS, and CSAM. These processes are implemented as virtual machines within the VSI framework.
- The visualization layer is based on the native Zabbix interface using PHP scripts.
- Export of data from the master database to CERN Technical Infrastructure Monitoring (TIM) and external Web-applications via Oracle database links. This is still work in progress.

Monitoring Improvements

PLC monitoring: SSM monitors PLCs using 2 basic approaches:

1. Simple alive checks using standard tools like ping, tracertool, to cover basic connectivity between servers and clients giving information about faulty machines between devices, DNS problems, and IP misconfigurations.
2. Active checks using scripts based on the LIBNODAVE libraries to get information from the diagnostic buffer of the PLCs, which is a buffer of diagnostics and alarms. An analysis of this buffer provides rapid detection of causes of errors. Alarms are triggered for events programmed in Zabbix for later tracking.

Trending and reporting: Trending has been improved in the new SSM with new overview screens for showing information.

OPC interface: The OPC interface connects the SSM with the PLCs and provides a complete list of alarms and equipped sensors, which are converted into predefined events and processed by the SSM. The SSM can send a script to any arbitrary task that returns a meaningful value to be measured. A freely available software package, OpenOPC, was used to interface from the Zabbix server running Java to an OPC server under Windows.

SSM server: Several access and safety systems use OPC servers, in particular, the new PS access and safety systems (PACS/PPS). The OPC interface is used to monitor PLCs and other systems using OPC interfaces.

Device specific views

Device specific views detail displays of specific subsystems or individual devices. Complex collections of graphs showing various aspects of the monitored systems can be created.

Left: A machine-specific view of a LACS operator pod at the Atlas experiment. Shown are graphs for CPU and memory loads, disk utilization, and network traffic.

Right: A global view of a lot of outstanding issues in various devices. Colors indicate the severity of the issue, which means a critical issue requiring immediate action, light green an informational message.

Views from external systems

SSM offers a facility to display dynamic images from external sources as web pages. This allows one to use various on-line information pages as additional source of information to the maintenance and operation teams.

Right: Screenshots of the panel-PLC of the SPS access and safety system. A in-house system has been developed to take periodic screenshots (once per minute) of the various safety related information displays and panel-PCs around the site.

Left: Network traffic of SUSI video servers. The graphs show generally high incoming traffic (red graphs) whenever an on-site camera is recording.

Left: Disk utilization statistics of several SUSI video servers.

References

- SMART@ CERN: Safety at the frontier.
- CERN Technical Infrastructure Monitoring (TIM) - A master SSM/Zabbix server is connected to a local MySQL database, which stores all the monitoring data.
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Monitoring engine Zabbix

- New Zabbix
- Support for Windows, Linux, other Unis
- SNMP, IPMI, database monitoring, web monitoring, ...
- Extensible: server scripts, client scripts
- Proxy servers (monitor restricted networks). Implemented as virtual machines within the VSI framework.
- Local MySQL database for the best performance.
- Web interface out of the box (PHP – practically a drop-in).
- Can do mass updates using XML files.
- Robust (very few problems).
- Accessible within the access team.
- Active development and user groups.
- Free.

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2. Active checks using scripts based on the LIBNODAVE libraries. This method requires special programs and scripts to get information from the diagnostic buffer of the PLCs, which is a buffer of diagnostics and alarms. An analysis of this buffer provides rapid detection of causes of errors. Alarms are triggered for events programmed in Zabbix for later tracking.

Trending and reporting: Trending has been improved in the new SSM with new overview screens for showing information about its trends. Trending allows spotting problems of specific tools or discovering general infrastructure problems. It is a requirement for maintenance planning, for dimensioning of future if on hardware management. Development has been carried out to implement trend prediction using tools like R, but this work is still ongoing.

OPC server interface: The OPC server interface uses the so-called external check mechanism of Zabbix. The Zabbix server can script to any arbitrary task that returns a meaningful value to be measured. A freely available software package, OpenOPC, was used to interface from the Zabbix server running Java to an OPC server under Windows.

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SNMP interface: The new SNMP in Zabbix is able to read an existing MIB database of a device and build monitoring rules from it directly.

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Global views

Global views are synthesized views of the different systems offering a simple traffic-light-style view of the state-of-health of the entire system.

Right: A global view showing the overall subsystem status of some of the access and safety systems. Green indicates that everything is ok, while red would mean that there is a problem to be investigated.

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