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# THE ALARM SYSTEM AT HLS-II

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*Abstract*

The control system of the Hefei Light Source II (HLS-II) is a distributed system based on Experimental Physics and Industrial Control System. The alarm system of HLS-II is responsible for monitoring the alarm state of the facility and distributing the alarm in time. The monitoring scope of the alarm system covers the front end devices and the server systems of HLS-II. The alarm distribution strategy of HLS-II is designed to overcome nuisance alarms. Zabbix is an open-source software tool used for monitor the server systems. Custom metrics are collected through external scripts. The alarm system of HLS-II provides multiple ways to notify the responsible operators, including WeChat, SMS and web-based GUI. It facilitates the operator to troubleshoot problem efficiently, so as to improve the availability of HLS-II.

## INTRODUCTION

Hefei Light Source II (HLS-II) is a vacuum ultraviolet synchrotron light source [1]. HLS-II consists of e-gun, microwave, klystron, power supply, vacuum, resonator, undulator, beam diagnosis and other front end devices. Alarm system of HLS-II is inevitable component of control system that notify operators of abnormal conditions in time. The monitoring scope of HLS-II alarm system includes the front end devices of subsystems and the server systems.

The control system of HLS-II is a distributed system based on Experimental physics and industrial control system (EPICS). Phoebus/Alarms is the latest alarm software released in EPICS community [2–4]. The alarm system for the front end devices is designed based on Phoebus/Alarms [5]. To meet the requirement of HLS-II, the alarm distribution way, such as WeChat, needs to be customized. In addition, nuisance alarms are often observed under normal circumstances due to noise and disturbance. Therefore, it is necessary to design the HLS-II alarm distribution strategy to remove nuisance alarms.

In order to achieve comprehensive monitoring of the HLS-II control system, the monitoring of the server systems is included in the alarm system. Zabbix is widely used in large scientific facilities to resolve issues related to servers and applications, such as SuperKEKB, CERN Large Hadron Collider and the NSRL facility cluster [6–8]. Thus, Zabbix is selected as the monitoring tool for the server systems.

## OVERALL ARCHITECTURE

The alarm system of HLS-II monitors the abnormal states of front end devices and server systems. The architecture of the HLS-II alarm system is shown in Fig. 1. PVs represent various attributes of the front end devices. The alarm server monitors the PVs stored in Kafka topic and updates their alarm states in Kafka. Kafka is a distributed messaging service. It can store messages and then efficiently send all stored messages to newly connected client.

The server systems contain OPI servers, data archiver servers, database servers, web application servers and file servers, etc. Most servers are deployed on virtual machines created by VMware vSphere. The operating system of servers is Linux. Zabbix monitors metrics through Zabbix agents running on individual servers. The metrics are processed by the Zabbix server and then stored in the Zabbix database. The Zabbix Web provides graph graphing functionality.

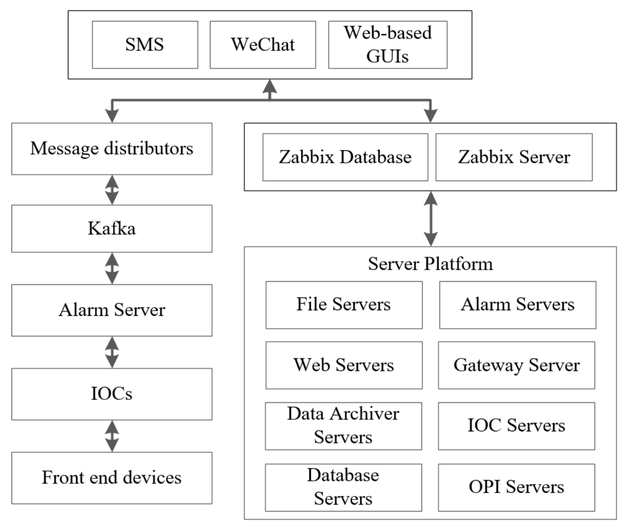


Figure 1: Architecture of the HLS-II alarm system.

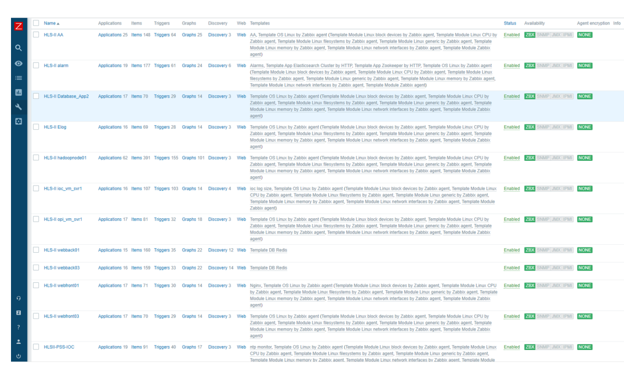

Figure 2: Screenshot of Zabbix web.

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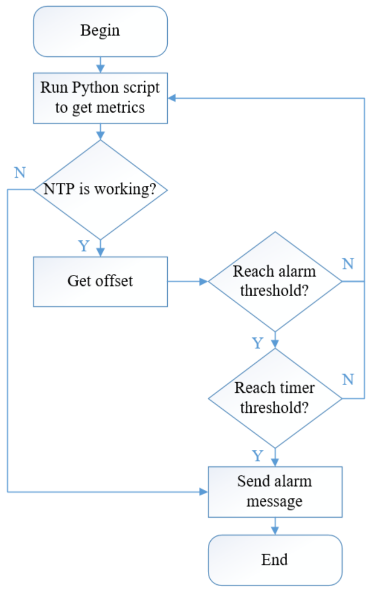


Figure 3: Flowchart of the alarm process of NTP status.

## ALARM DISTRIBUTION STRATEGY DESIGN

Nuisance alarms negatively impact the credibility of the alarm system and distract operators from identifying true alarms. In order to present the truly necessary alarms, the distribution strategy of HLS-II alarm system needs to be design. There are five alarm management methods used in strategy design.

### *Alarm Deadband*

Alarm deadband is a hysteresis field of PV. It keeps a signal that is hovering at the limit from generating too many nuisance alarms. Alarm deadband is suitable for analog input records with small deviation from alarm threshold.

### *Delay Timer*

The m-sample delay timer raises (clears) alarms if and only if m consecutive samples are in the alarm (non-alarm) state. The delay timer results detection delays of abnormal conditions.

### *Alarm Severity*

The alarm severity is used to give weight to the current alarm state. There are five alarm severities defined in alarm server which are OK, MINOR, MAJOR, INVALID and UNDEFINED. The alarm severity corresponds to the cause and the risk of the alarm.

### *State-Based Alarm Methodology*

State-based alarm methodology produces dynamic alarm methods based upon HLS-II modes. HLS-II is operated with four modes, which are shutdown, maintenance, machine study and user operation. For example, the alarm system only needs to track the alarm state of the vacuum system, temperature monitoring system and personnel safety.

### *Group Alarm*

Group alarm produces a representative alarm by combining several similar alarms to avoid redundant information. When an IOC application itself encounters an abnormal state, the corresponding devices failure or the communication interruption occurs, the multiple PVs of the IOC will enter alarm state, and then a lot of redundant alarm messages from this IOC will be sent in a short time.

## SERVER SYSTEMS MORNITORING

Table 1: Monitored Objects, Templates, Items and Item Types

| **Monitored objects** | **Templates** | **Items** |
|---|---|---|
| Server | Template OS Linux by Zabbix agent | CPU, Memory, Disk, Network, Inventory,etc. |
| Zabbix Server | Template App Zabbix Server | Queue, Configuration, cache, etc. |
| Redis | Template DB Redis | Redis status, Memory, etc. |
| Zookeeper | Template App Zookeeper by HTTP | Zookeeper status, connection, etc. |
| Elasticsearch | Template App Elasticsearch Cluster by HTTP etc. | Service status, Cluster health status etc. |
| IOC log | Template IOC | IOC log size |
| NTP | Template NTP Service | Clock synchronization status |

Zabbix collects and monitors various metrics to evaluate systems and applications performance. For efficient deployment, Zabbix provides various templates. The templates contain items, triggers, graphs, etc. Table 1 lists some monitored objects, their templates and items applied in the HLS-II alarm system. As shown in Fig. 2, Zabbix web lists the monitored hosts information.

The Network Time Protocol (NTP) server is monitored through customized item. NTP is an internet protocol used to synchronize with computer clock time sources in a network. The python script monitor clock synchronization performance through the ntpq program. The Zabbix agent runs the python script in monitored hosts and provides the metrics to the Zabbix server. Figure 3 depicts the alarm process of ntp time synchronization. This metric has millisecond-level time synchronization accuracy.

The alarm messages are distributed to WeChat, SMS and the web-based GUI. Figure 4 shows the screenshot of the WeChat messages.

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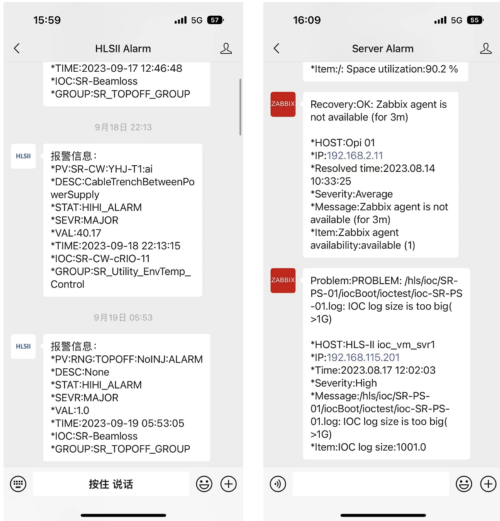


Figure 4: Screenshots of the WeChat messages of the alarm system.

## CONCLUSION

The alarm system of HLS-II has been deployed since 2021 and the server systems monitoring has been incorporated since December 2022. The result shows the alarm system of HLS-II facilitates the operator to troubleshoot problem. The alarm strategy realizes the filtering of nuisance alarms. The number of alarms distributed through WeChat and SMS is generally less than 30 messages per day. The predefined templates and native GUI of Zabbix reduce manual configuration efforts. Zabbix custom items can be flexibly customized to meet the HLS-II requirement.

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