

Fault Detection and Diagnosis Software For LHAASO

Large High Altitude Air Shower Observatory (LHAASO)



Collect Layer

Agent

Computing Nodes

Agent

Switches

Agent

Dataflow Software

Analysis Layer



Expert Database

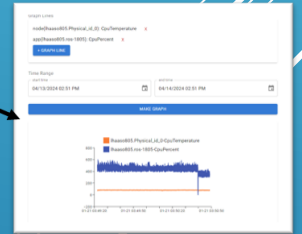
Fault Detection
Threshold/SMA

Root Causes
Analysis

Result Layer



Alerts: Email, Wechat, etc



Web

Collect metrics from online computing system, including software and hardware

Using numerical statistical methods to determine if there is a fault, and utilizing graph similarity algorithms to identify the root cause of the fault.

Report the analysis results in multiple ways

Fault Detection and Diagnosis Software For LHAASO



Purpose

Methods

Conclusion

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Fault Detection and Diagnosis Software For LHAASO

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Introduction

The Large High Altitude Air Shower Observatory (LHAASO) mainly aims at exploring the origin of high-energy cosmic rays and conducting scientific researches on high energy astrophysical radiation. LHAASO is located 4410 meters above sea level (a.s.l.) on Mt.Haizi in Daocheng County, Sichuan Province, China, and covers an area of 1.36 km². By employing hybrid measurements of extensive air showers (EAS) through the detector arrays, LHAASO achieves unparalleled sensitivity in detecting ultra-high-energy gamma rays and conducting all-sky surveys for very high-energy gamma ray sources. Additionally, it will provide measurements of the energy spectrum of cosmic rays across an exceptionally broad energy range.

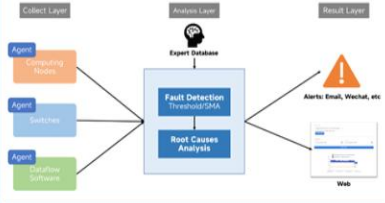


Experimentation on a Large Scale
Comprehensive Status Detection

Complexity of Online Computing System
Failures are inevitable
Fast Fault Monitoring

Requirements for Non-stop Running
Quick diagnosis of the cause of the failure is key, need a software tool.
Rapid Analysis of Fault Root Causes

Structure



Fault Detection

Exception

- Exceeds the standard range
- Not yet affected Online Computing System

Fault

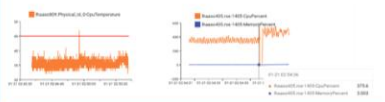
- Causes an interruption of Online Computing System
- Occurred shortly before the interruption

Based On Threshold

- Setting the upper and lower thresholds
- Apply to CPU temperature, memory utilization


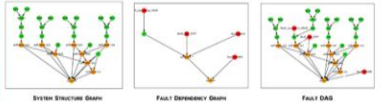
Based On Simple Moving Average

- Better representation of data volatility
- Applied to metrics where stability needs to be assured
- CPU Percent
- Software Performance



Fault Diagnosis

- Formation of Fault Dependency Graph **Expert Database** by experts
- Formation of **System Structure Graph** based on system architecture
- Formation of **Fault DAG** based on System Structure Graph in case of faults
- Compare with the expert database for **DAG similarity judgment** and get the root cause of the fault.

Metrics Collection

Agent:


- Quick deployment
- Flexibly deployable
- Modular monitoring design

Master:

- Batch running tool
- Associated with experiment
- Run automatically

klog_online / Dataflow Collect Package:

- C++ dynamic library
- Running the DAGs system
- Collecting performance of time fragment



Metrics	Source	Time Interval (Second)
CPU utilization	Software	5
Memory utilization	Software	5
CPU temperature	Computing Node	5
Switch Port Connectivity	Switch	5
Software Performance	Software	-

Conclusion

Application on LHAASO Online Computing System

- Improvement of fault monitoring efficiency
- Assist duty personnel to reduce the burden
- Automatic generation of operation reports

Next step:

- Determine whether a fault has occurred based on machine learning methods
- Analyze the root cause of faults based on graph neural networks

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Structure

- Applied in LHAASO
- Effectively reducing maintenance pressure
- Improving operational quality.

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