Status and Operation of LHAASO Computing Platform

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Computer Center, IHEP

Outline

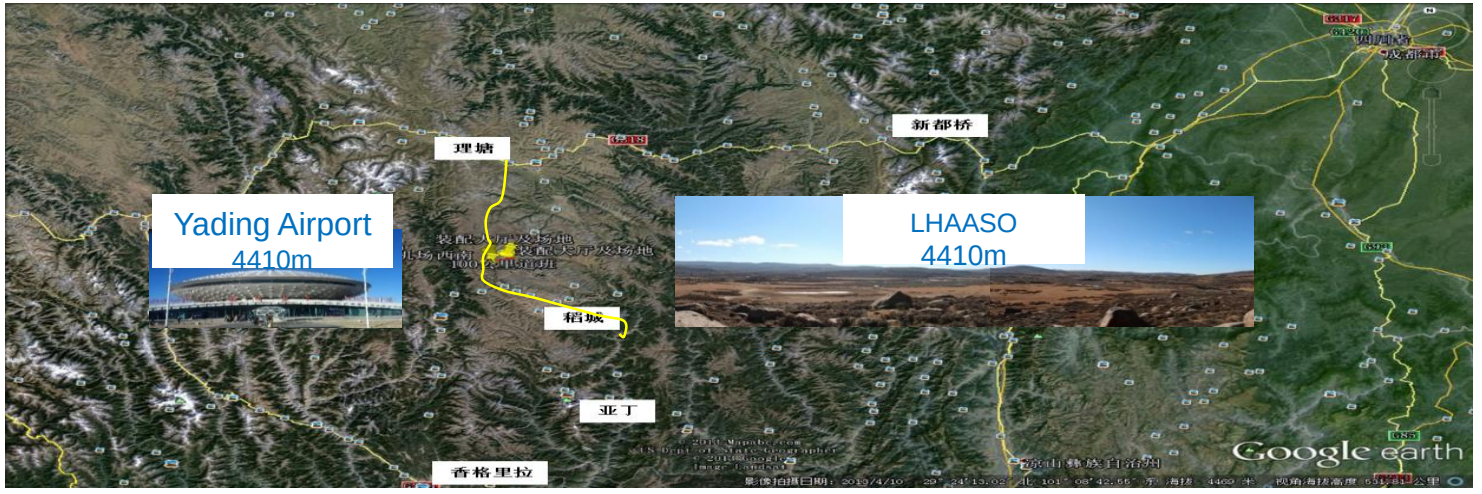
- Brief introduction to LHAASO
- LHAASO computing status
  - Container virtualization
- Distributed Monitor
- Summary

Large science facilities of IHEP

- IHEP: The largest fundamental research center in China
- IHEP serves as the backbone of China's large science facilities
  - Beijing Electron Positron Collider (BEPCII/BESIII)
  - Yangbajing Cosmic Ray Observatory (ASg & ARGO)
  - Daya Bay Neutrino Experiment
  - China Spallation Neutron Source (CSNS)
  - Hard X-ray Modulation Telescope (HXMT)
  - Accelerator-driven Sub-critical System (ADS)
  - Jiangmen Neutrino Underground Observatory (JUNO)
  - Large High Altitude Air Shower Observatory (LHAASO)
  - High Energy Photon Source (HEPS)
  - Under planning: XTP, HERD,CEPC …

LHAASO: Large High Altitude Air Shower Observatory

- Mt. Haizi (4410 m a.s.l., 29°21’ 27.6” N, 100°08’19.6” E), Sichuan, China
- An major infrastructure project of 12th Five-Year Plan
- A new generation all-sky instrument to perform a combined study of cosmic rays and gamma-rays in the wide energy range 10 TeV -- 1 EeV
- Funded mainly by China, 20+ institutions joining the collaboration
- LHAASO Scientific Goals
  - Origin of galactic cosmic rays
  - Gamma ray astronomy
  - New physics frontier (dark matter, Lorentz invariance…)



Computing Requirements

- ~6 Petabytes of data annually generated by the LHAASO detectors
  - 6 PB of raw data, and >200TB of reconstruction data
  - Totally >60PB for ten years
- >2 Petabytes of data generated by MC simulation
- To build one distributed computing system containing about 6000 CPU cores to process the data
  - ~ 4500 CPU cores for reconstruction, analysis, …
  - ~ 1500 cores for production

Offline data processing workflow

- Computing farm includes local site(Beijing) and on site (Daocheng)
- After the experimental data is acquired by DAQ, it enters the offline computing platform
- Provide support services for data storage, transmission, sharing, analysis and processing

On-site data center at Haizi Mountain observatory (4410m)

~2000CPU cores and 700TB disk storage for calibration and rapid reconstruction

~300Mbps

Operation center at Daocheng city

~1Gbps

Beijing Computing sites

Current LHAASO computing environment

- Daocheng Observation onsite
  - DAQ, data filtering, fast reconstruction, compression, etc.
  - Transfer raw data and fast reconstructed data to main center
- Beijing local cluster
  - Storage of all data (raw, reconstructed, simulated, analyzed, etc.)
  - All data reconstruction computation
  - Distribution of reconstructed data to sub-centers
  - Receiving simulation and analysis data from the sub-center
- Distributed monitoring
  - Web page and alarm system for operator and administrator

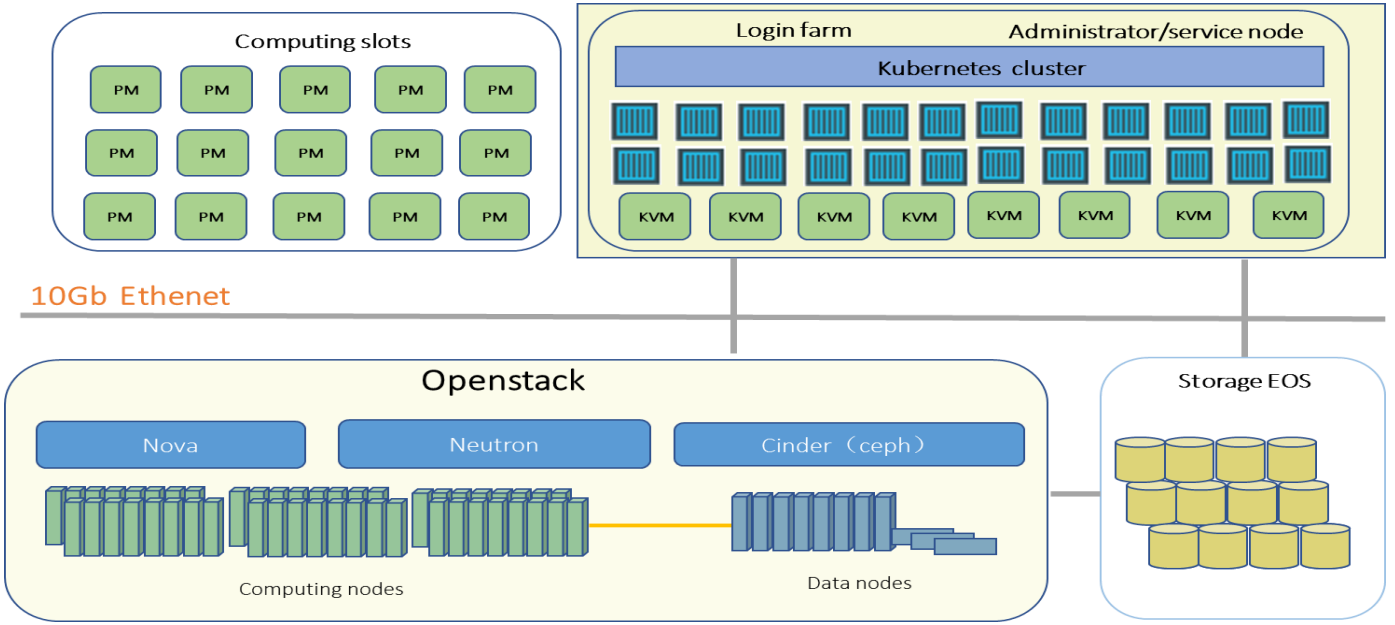
Site	Function	Computing	Storage
DaoCheng Onsite	fast reconstruction	468 Cores	700 TB
Beijing Local Cluster	Data reconstruction and analysis	15,000 Cores	2.4 PB

Motivation & Challenges

- The Onsite at high altitude, high cost for operation and maintenance
  - Computing system instability of remote sites
  - Man power for maintenance is poor
  - Unstable power supply and network connection
- Not enough physical machines to run services onsite, only 20+ physical machines
- Virtualization and cloud computing technologies
  - Virtualization technology to hide the underling details
  - Reduce the cost of operation and maintenance greatly
- No typical experiment software
  - Several OSes are requested

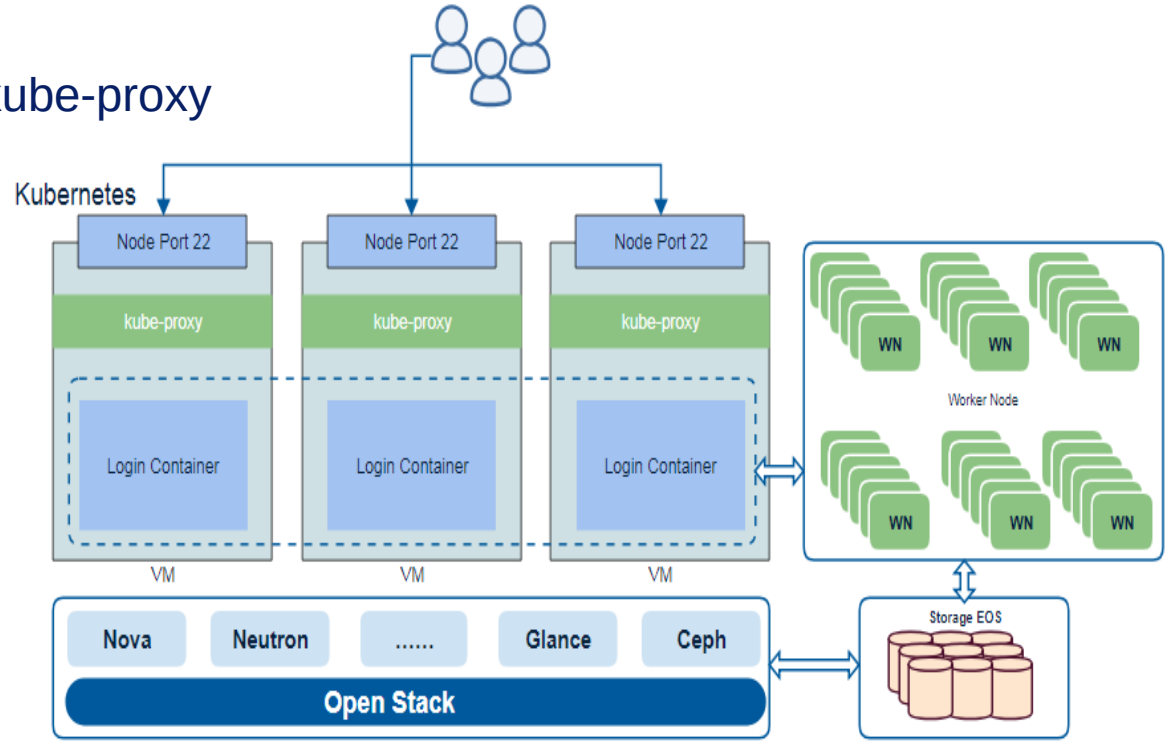
Cloud-based computing farm onsite

- Login Node
  - Login container on vm, kubernetes manage login nodes pods
  - Load balancing
  - Easy to scale and recover
- Administrator/Service node
  - Vms for Htcondor/Monitor/Puppet…
- Computing node
  - Physical machine, support singularity container jobs



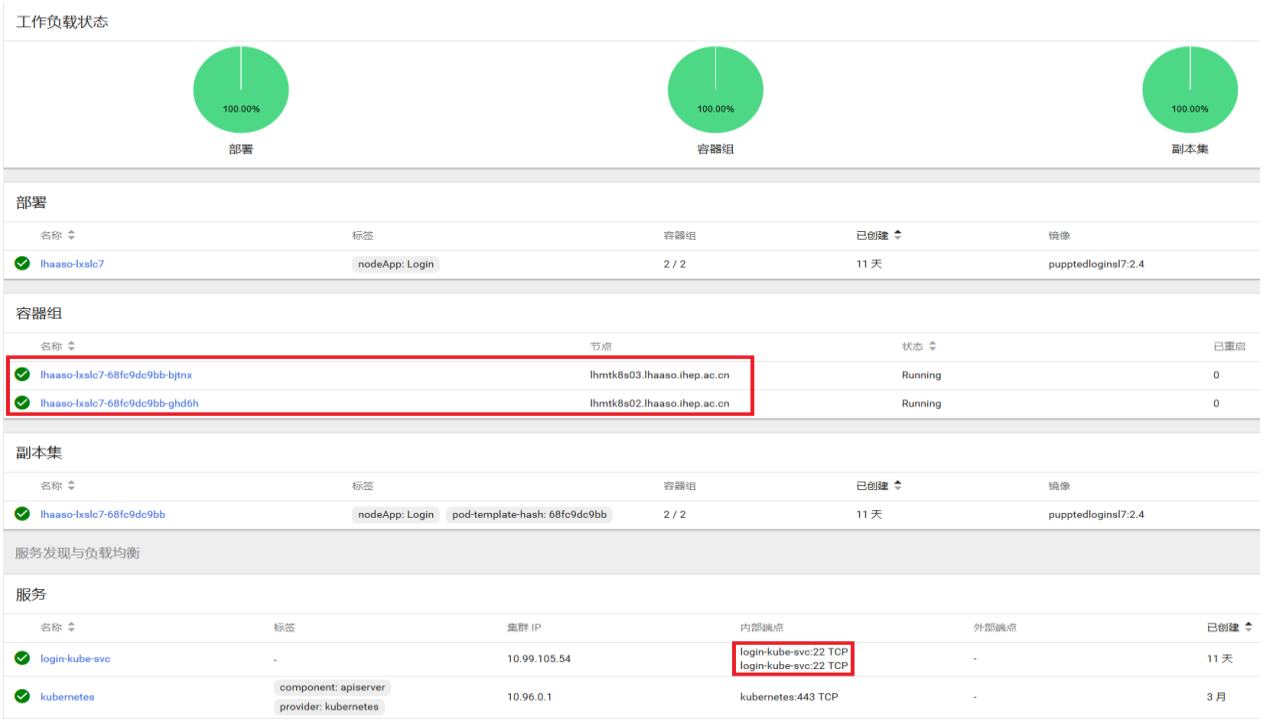
Login Nodes

- Containers run on the VM provided by openstack
  - SL7 container image, scheduled by kubernetes
  - AFS/CMVFS/EOS mounted
  - Singularity support
- Load balance
  - Expose ssh 22 port
  - Round-Robin Scheduling by kube-proxy
- Auto dynamic expansion
- Stable and highly available
  - Auto restart container if err happens

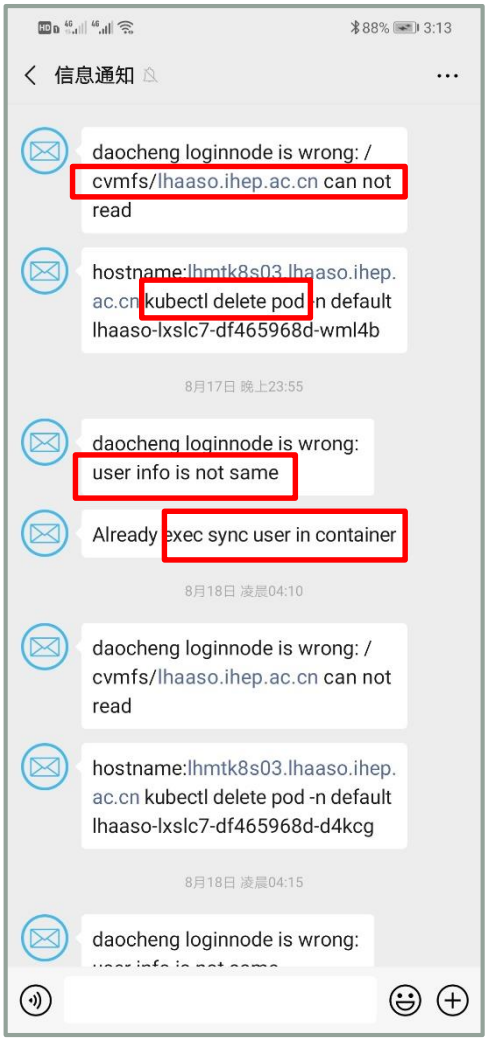


Login Node environment

- PM OS
  - CentOS 7.6
- VM Instance OS
  - SL 7.5
- Container OS
  - SL 7.5
- Openstack Queens(RDO)
- Kubernetes
  - 1master+2slave
  - Version 1.12.0



Recovery example



detected /cvmfs err

Del err pod container, start a new one

User info not sync, exec sync script in container to update user info

Auto scale

- According to the system load and the number of users login, set the number of pods, automatically scale up and down
- Auto scale up login pods
  - kubectl scale --replicas=3 -f login.yaml
- Auto scale down specific pods
  - delete replication controller
  - delete the non user login pods
  - recreate replication controller of size 2

Work node

- Physical machine
  - OS SL7.6
  - Installed and managed by puppet+forman
- Singularity support
  - Lightweight compared with docker
  - SL6.9 and SL5.5 image
  - AFS for container image distribution
  - AFS home directory and EOS for data directory mounted

Administrator node

- VM nodes
  - Improve resource utilization，not enough hosts
  - Use ceph storage
- VM vs container
  - Better isolation
  - Virtualize NIC, Flexible network configuration
  - Independent kernel
- Administrator nodes support service
  - Htcondor schedule server
  - Nagios distributed agent
  - Ganglia local server
  - Mirror http web for OS and Software
  - Data transfer severs

Hep_container tool

- A container tool developed for IHEP and distributed sites(Daocheng\PKU\USTC)
- Based on singularity, satisfy users' various OS requirements
- Automatically mount the experimental directory according to the user's uid and gid to protect data security

```
[zhengw@lxslc701 ~]$ ./hep_container help

Usage : ./hep_container  <command> [command options...]
CONTAINER USAGE COMMANDS:
    shell            Run a Bourne shell within container image
    exec             Execute a command within container image
    images           List Support container images
    groups           List Support groups
    -g groupname     With a specific group name
EXAMPLES:
    ./hep_container images
    ./hep_container groups

    ./hep_container shell SL5
    ./hep_container shell SL5 -g physics

    ./hep_container exec  SL5 cat /etc/redhat-release
    ./hep_container exec  SL5 python ./yourprograme.py
    ./hep_container exec  SL5 -g physics cat /etc/redhat-release

[zhengw@lxslc701 ~]$ ./hep_container images
Hep_container support images:
        SL5 : Scientific Linux 5
        SL6 : Scientific Linux 6
[zhengw@lxslc701 ~]$ ./hep_container groups
Hep_container support groups:
        u07|atlas|atlasrun|comet|offline|physics|higgs|ams|cms|dyw|hxmt|polars|juno|argo|lhaaso|
```

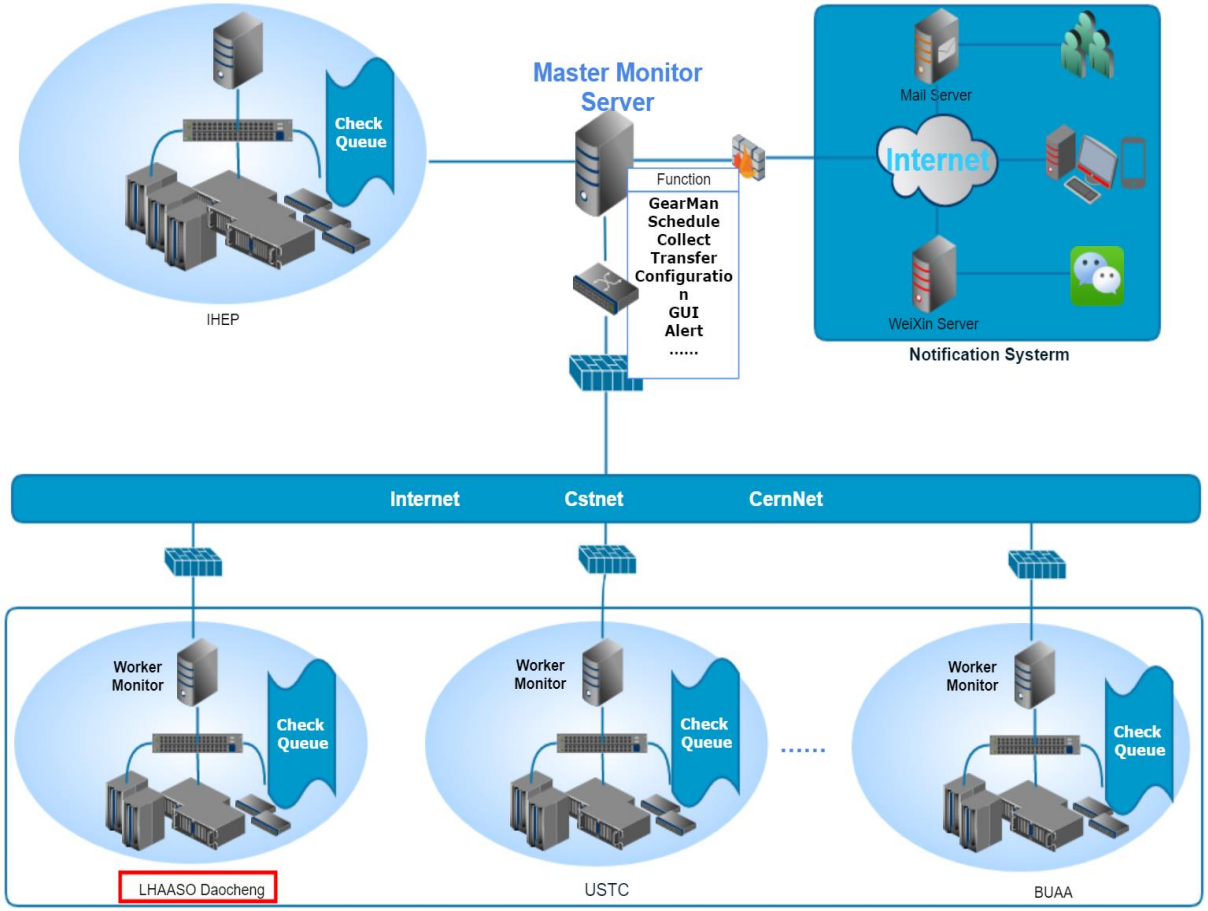
Distributed unified monitoring

Central Site: IHEP

- Nagios V4 integrate with Mod_gearman
- Central site receive metric report from remote site
  - 5 sites &1,600+ hosts &18,000+ metric

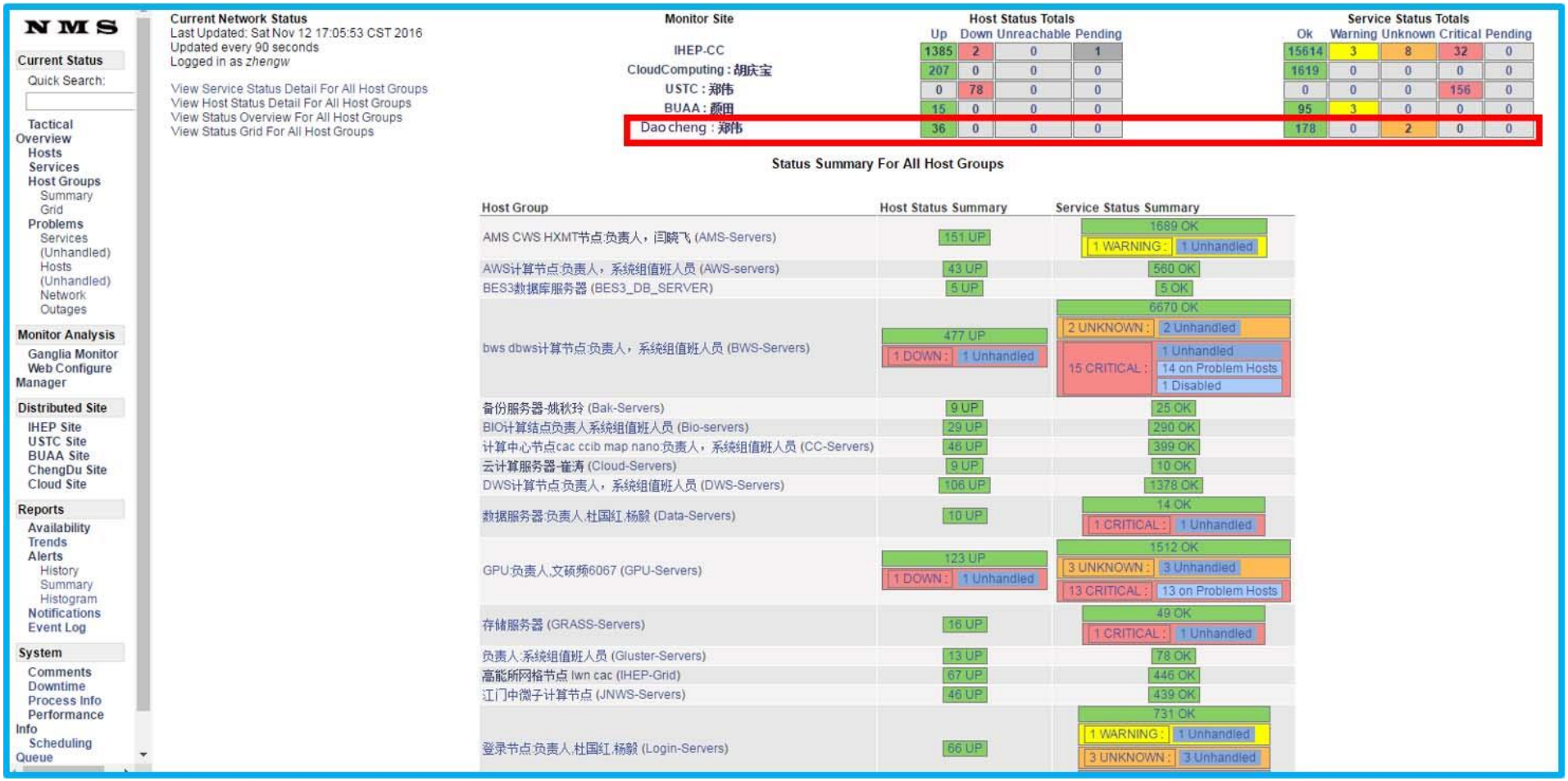
- Daocheng onsite
  - Reports site own info to central site
  - 1 worker node 5 workers

- Monitoring period for all metric is less than 2 mins



Unified Dashboard

- Daocheng site monitoring has been added into IHEP monitoring system.



Monitoring performance of LHAASO

- 36 hosts and 178 services
- Hosts monitoring period <=5mins, mostly < 1mins
- Services monitoring period <=5mins, mostly <1 mins

Host Group	Host Status Summary	Service Status Summary
lhaaso-本地监控 (lhaaso-local)	5 UP	5 OK
lhaaso 计算节点 (lhmt-worknode)	13 UP	85 OK 6 WARNING : 6 Unhandled
lhaaso cloud server (lhmtcloud)	3 UP	3 OK
lhaaso eos servers (lhmteos)	2 UP	12 OK 1 WARNING : 1 Unhandled 1 CRITICAL : 1 Unhandled
lhmt-k8s-cluster (lhmtk8s)	3 UP	16 OK
路由器 (lhmtrouter)	2 UP	2 OK
lhmt调度服务器 (lhmtsched)	2 UP	9 OK

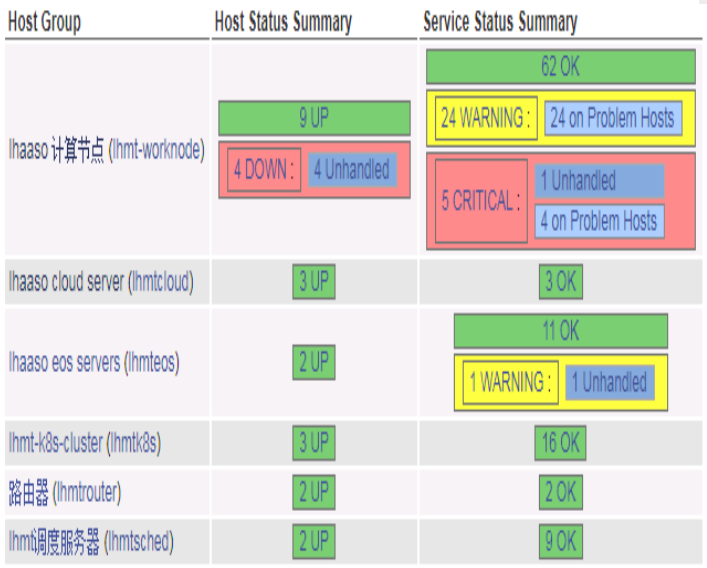
Hosts Actively Checked:

Time Frame	Hosts Checked
<= 1 minute:	1134 (85.3%)
<= 5 minutes:	1328 (99.9%)
<= 15 minutes:	1328 (99.9%)
<= 1 hour:	1328 (99.9%)
Since program start:	1328 (99.9%)

Metric	Min.	Max.	Average
Check Execution Time:	0.00 sec	7.50 sec	4.017 sec
Check Latency:	0.00 sec	0.93 sec	0.465 sec
Percent State Change:	0.00%	0.00%	0.00%

Notification

- Timely and accurate alarm notification
  - Notify the system administrators at the first time
- Alarms: Web page, WeChat, Email, SMS



**** PROBLEM Service Alert: lhaaso路由器-山上/ch eck_pingis WARNING ****

发件人： keb_fast@163.com

收件人： zhengw@ihep.ac.cn

```
***** NMS *****

Notification Type: PROBLEM

Service: check_ping
Host: lhaaso路由器-山上
Address: 125.67.5.88
State: WARNING

Date/Time: Mon Apr 1 15:51:05 CST 2019

Additional Info:

PING WARNING - Packet loss = 20%, RTA = 84.95 ms
```

Summary

- Cloud based Daocheng onsite runs well
- Try to make LHAASO resources keep high utilization
- Rapid recovery after site failure
- Operation and maintenance of LHAASO site is benefit from the distributed monitoring and alarm system

Thanks for your attentions!

谢谢！