Resources monitoring and automatic management system for multi-VO distributed computing system

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Abstract. Multi-VO supports based on DIRAC have been set up to provide workload and data management for several high energy experiments in IHEP. To monitor and manage the heterogeneous resources which belong to different Virtual Organizations in a uniform way, a resources monitoring and automatic management system based on Resource Status System (RSS) of DIRAC has been presented in this paper. The system is composed of three parts: information collection, status decision and automatic control, and information display. The information collection includes active and passive way of gathering status from different sources and stores them in databases. The status decision and automatic control is used to evaluate the resources status and take control actions on resources automatically through some pre-defined policies and actions. The monitoring information is displayed on a web portal. Both the real-time information and historical information can be obtained from the web portal. All the implementations are based on DIRAC framework. The information and control including sites, policies, web portal for different VOs can be well defined and distinguished within DIRAC user and group management infrastructure.

1. Introduction

Multi-VO supports based on DIRAC have been set up to provide workload and data management for several high energy experiments in IHEP [2]. Many heterogeneous sites have been plugged in the distributed computing system in a similar way by DIRAC acting as an abstraction layer. The site can be a CLUSTER site constructed using PBS or Condor, a CLOUD site implements with OpenStack or OpenNebula, or a GRID site. These sites provide various types of resource, such as computing element, storage element, for all the registered VOs. Every VO can access corresponding resources to support their research.

A monitoring and management system is required to ensure the distributed sites and resources work stably and reliably. It should take all of the heterogeneous into account and satisfy the different requirement between VOs. Adopting the idea from Resource Status System (RSS) of DIRAC [3][4], this paper designs such a monitoring system based on RSS. The monitoring system will gather monitoring information combining with passive monitoring and active monitoring. On one hand, it will collect information from different sources, which can be other monitoring tools provided by different projects. On the other hand, it will execute various tests for resources to collect availability
information. The collected information will be displayed by web and be the basic to manage the resources automatically.

This paper introduces the monitoring and management system as follows: section 2 presents the purposes for designing such a monitoring system. Section 3 gives a brief introduction about the resources monitoring and automatic management system. Section 4 gives the system implementation. Finally, conclusions are given in section 6.

2. Purposes
The purposes of this monitoring and management system can be summarized as follow:

- Monitor and manage all the heterogeneous resources in a unified way.
- Support for multi-VO to satisfy their special requirements.
- Collect the dispersed monitoring information from different sources.
- Collect resource availability information through active tests.
- Expose a single endpoint to fetch the collected information.
- Evaluate the resource status by combining the collected information and achieve automatic management according to the status.

3. Monitoring and Automatic Management System
The resources monitoring and automatic management system is divided into three parts: information collection, status decision and automatic control and information display.

1) Information collection: collect the interested information which scattered in different sources by passive and active way.

2) Status decision and automatic control: similar to RSS, use policies to evaluate the status of resources and execute actions according to the status.

3) Information display: display both monitoring and control information through webpages. Real-time information is provided as well as historical information.

3.1. Information Collection
It is a difficult and complex task for an administrator of the distributed computing system to handle and track the widespread information sources by manual. Collecting the dispersed information and providing a single endpoint to access these information is the primary purpose for a monitoring tool. This system collects monitoring information in both passive and active way and caches them locally.

3.1.1. Passive Monitoring. Passive monitoring means to collect the information created by other tools. The information can be the efficiency of jobs, storage element occupancies or other interested information. It is achieved depending on the commands which presented by RSS. Each command is in charge of collect certain information from one source. Different commands can be developed to collect various information.

3.1.2. Active Monitoring. Active Monitoring is an effective way to monitor the availability of sites. A series of standard tests can be defined and be executed for all the sites to test their availability. These tests may send some test jobs to the sites. The test jobs are well defined and won’t be failed if the site is fine. So it must have something wrong with the sites and resources once any test fails.

Every site holds some different types of resources. An idea for test design is developing one test for one type of resource. But it is coarse-grained and difficult to track the problem of the resources. To improve this design, such one test can be divided into several tests. Each one of the test provides different availability perspectives about the same resource. For example, for computing element, CVMFS test can be defined to test the distributed file system; also BOSS test can be defined to test the software which is used to run the users’ jobs. With a well-designed test structure, it will be easy to find out the problems.
Since the job’s runtime environment is quite different between different VOs, every VO has its special requirement about the tests. In order to support multi-VOs, customization must be allowed for all the VOs to develop their dedicated tests.

3.2. Status Decision and Automatic Control
DIRAC Resource Status System (RSS) has been used to achieve the resource status decision and automatic control. The status of resources is evaluated by applying a number of policies. Each policy defines the rules judging the status with specific monitoring information. Combining the results of all applied policies, a reasonable status is given to mark the final status of resources. Then some actions will be executed according to the final status. These actions can be alarm actions such as send emails, or control actions such as ban the bad sites.

3.3. Information Display
A web portal has been designed as the uniform endpoint to obtain the collected monitoring information. Both real-time information and historical information are displayed on the web portal. For the real-time information display, a summary page gives a quick view of all sites status and the detail information can be obtained by tracking down from the top. For the historical information, the tests historical information has been displayed to give a global view of resources status for certain period of time.

The web portal provides a VO-centric view of the monitoring information. Each VO can only see the resources and information which is related. For BES users, they can’t see the information of the sites belong to CEPC, and can’t see the CEPC’s test results.

4. System Implementation
This system is developed based on DIRAC Resource Status System. A DIRAC system includes four necessary components, DB, Client, Service and Agent [1]. With these components, follow functional modules are implemented:

- Commands
- Test System
- Policy System
- Web Portal

4.1. Commands
Command is the concept proposed by RSS. It is used to collect and cache the monitoring information from external sources. Each command will connect to one source and obtain the interested information. A cache agent has been developed by RSS to run the configured commands periodically.

4.2. Test System
The Test System is in charge of executing tests for all sites to collect availability information. Figure 1 shows the structure of Test System. A test agent will work at regular intervals. It will read the tested resources from CS and load the tests configured in TestConfiguration file, then request Test System to execute tests and evaluate availability status of resources. TestExecutor will execute the matched tests for each resource and call StatusEvaluator to get status. StatusEvaluator will evaluate availability status for resources according to the results of the applied tests.

4.3. Policy System [3]
The RSS Policy System has been used to decide resources status and control the resources automatically. It uses policies to judge the status and takes actions after the status decision. As figure 2 shows, inspector agents will work periodically to run the Policy System. They will query RSS DB for the resources which have not been checked lately and call the Policy System for a new status. PIP will connect to CS to find out the policies which should be applied. PDP will evaluate these policies to get
a new reasonable status using the state machine. Then PEP will take some actions according to the new status.

![Test System Architecture](image1)

**Figure 1.** Test System Architecture.

![Policy System Architecture](image2)

**Figure 2.** Policy System Architecture.

4.4. **Web Portal**
The web portal was developed based on WebAppDIRAC framework. It includes two webpages, a real-time information page and a historical information page. The real-time information webpage is showed in Figure 3. For each site, the summary information is displayed on the top page in the form of table, as shown in figure 3(a). The detail information can be obtained tracking down from the top, such as the applied tests results shown in figure 3(b) and jobs statistics of the work nodes shown in figure 3(c) for a certain site. For each test, the log information can be got to find out the reason for the problems. Figure 4 shows the log of the BOSS test.
The tests historical information can be obtained from the historical information webpage. It will display the historical information in three different granularities, total availability, availability status for each period of time and tests results for each period of time. Figure 5 to figure 7 show this webpage.
5. Conclusions
In this paper we presented a resource monitoring and automatic management system and it has been used within the IHEP distributed computing system. It collects monitoring information by passive and active way. The VO dedicated tests are allowed to achieve the support for multi-VO. It also acts as a decision and control tool. It will take a status decision depending on the collected information and then take some actions to manage the resources automatically. We have designed a VO-centric web portal...
to display the real-time and historical monitoring information. This system has work effectively to ensure the stability and reliability of the IHEP distributed computing system.

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