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A simulation cloud monitoring framework and its evaluation model

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ABSTRACT

Simulation Cloud can help users to carry out the simulation tasks in various stages quickly and easily by renting instead of buying all the needed resources, such as the computing hardware, simulation devices, software, and models. A monitoring system is necessary, which can dynamically collect information about the characteristics and status of resources in real time. In this paper, we design a Simulation Cloud Monitoring Framework (SCMF), which is a Monitoring Framework based on Simulation Cloud. The main functions of SCMF include: 1. Collecting performance information of Simulation Cloud (including physical resources and virtual resources). 2. Processing the collected performance information, providing ranking information about resource consumption as the customized service to service layer. 3. Detecting abnormal behaviors on Simulation Cloud in real time.

The SCMF is based on hierarchical design. It consists of Root Monitoring Node (RMN), Federation Monitoring Node (RMN), and Main Monitoring Node (MMN). There is only one RMN in SCMF. It is responsible for collecting metadata about Simulation Cloud. For robustness, there are several FMNs in a federation. One is primary FMN and others are backup FMNs. MMN is implementing on every host in Simulation Cloud., MMN is responsible for collecting performance information about the host and virtual nodes. In the paper, it designs Sequence-Bucket strategy, which supports quick response for ranking information about resource consumption. It also designs two strategies: Rank-FMN (Federation Monitor Node) strategy and Huffman-Like Strategy. Huffman-Like Strategy combines small federations to reduce total consumption of SCMF, while Rank-FMN strategy is a load balancing strategy, which relieves the bottleneck of FMNs and spreads the loads equally among FMNs. The characteristics of SCMF are real-time, scalability, robustness, light weight, manageability, and archivability. Meanwhile, we design evaluation models for SCMF, which can provide quantitative results of monitoring accuracy and monitoring cost. The simulation results show that SCMF is accurate, low cost and can response in real-time.

1. Introduction

Cloud computing [7,11,13–15,29] has become a hotspot, to which both academia and business community are engaged. While it provides enormous advantages, cloud computing brings us a lot of technical challenges, such as monitoring in the cloud.

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When a distributed system makes resources scheduling and optimization, it needs to collect and analyze the performance information of all resources in the system, either physical or virtual [29,30]. Furthermore, the complexity and heterogeneity of the applications running on the distributed system can be volatile. To ensure the robustness, the system needs monitor modules to detect any abnormal behaviors and make fault-tolerance decisions in real-time. Finally, the archive of monitoring data will provide the conditions of resources utilization and users' behaviors, which are important for system development and making future decisions for business.

There are a number of excellent monitoring software packages implemented in the clusters, such as Ganglia [1,8] and Nagios [4]. In the grid [19–21], there is a method of Grid Monitoring Architecture (GMA) [2,5], on which a lot of efficient grid monitoring systems are developed, such as NWS [3], Remos [24,25], and MDS [22].

In this paper, we present the design and implementation of a monitoring framework in the Simulation Cloud platform. In this research, address the following technical challenges.

1. Monitor heterogeneous resources. There are different resources in the Simulation Cloud platform. For example, the Simulation Cloud system not only provides physical resources, but also virtual resources. Meanwhile, there are different operating systems in the Simulation Cloud system. Some instances may implement Windows operating system, while others may implement Linux.
2. Reduce the overhead of running the monitoring middleware. The Simulation Cloud platform is a large system that provides tremendous computing and storage utility for users. The monitoring middleware should not be a big burden of the Simulation Cloud platform and consume as little resource as possible. As the Simulation Cloud platform supports dynamically increasing and reducing resources, the middleware should scale well with different number of nodes in the system, and any component should not become the bottleneck of the monitoring middleware.
3. Detect anomalous status of resources, either physical or virtual, such as network failure, overloaded nodes, and virtual instance fault. The monitor middleware should catch and send anomalous information to the higher level for fault handling.
4. Automatic resource discovery and configuration. It would be a disaster if we had to make new configuration each time when Simulation Cloud platform makes a change. The monitoring middleware should be aware of the changes of resources in system and immediately take response automatically.
5. Monitor virtual resources: many grid monitoring systems are good at monitoring physical resources. However, we'll meet new challenges when monitoring virtual resources in the Simulation Cloud. We should not only obtain performance information about virtual machines, but also immediately detect fault in the virtual machines. Based on the information, we can then implement the fault-tolerance and migration mechanism of simulation resources.

2. Background

Modeling and simulation technique is tagged with the terms "digital, virtual, networked, intelligent, integrated, and collaborative". Especially, the emerging Simulation Grid [6,31] overcomes the limitations of the traditional HLA in dynamic resource sharing, self-organization, fault tolerance, interoperability and security mechanism. On the one hand, it extends the model of distributed-simulation application and implements new methods of co-simulation based on grid computing. On the other hand, it extends the traditional computing grid and data grid by adding support to collaborative work.

However, the services in simulation grid are limited to the software application level. Simulation grid cannot provide effective management and reuse for the underlying layer, such as the layer of computing resources and operating system. It is difficult for users to shield heterogeneity of simulation resources. Because of the single user simulation environment, a simulation grid cannot meet new demand of simulation.

With the emergence of cloud computing, the environment can provide tremendous computing capacity and efficient services for users. Simulation Cloud platform [23] supports a new simulation model – "Simulation Cloud" mode, which organizes a variety of simulation resources on demand through the Internet and cloud-simulation platform and provides the user a variety of modeling and simulation services. The Cloud consists of Cloud service providers and registered Cloud users. Firstly, as the support of security system, users define the need of simulation tasks through the portal of Simulation Cloud platform. According to user demand, Simulation Cloud platform will be able to automatically find the necessary resources (Simulation Cloud) and construct the "service" with a combination of on-demand application. Then the "service" under the dynamically controlling of Simulation Cloud platform will carry on network modeling simulation to complete the "Simulation Cloud" (Fig. 1).

Simulation Cloud has several advantages:

(1) Simulation platform as a service center provided to the user, which supports the reuse of resources and fine-grained resource sharing. Users can quickly carry out simulation work without any complex preparation.
(2) Multiple users apply the online platform simultaneously and management of multiple simulation tasks is available.
(3) Unified user authentication and multi-use single sign-on mechanism.
(4) Complete security system to ensure an efficient and stable platform.