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Research of elastic management strategy for cloud storage

[1]SHAO Bi-lin, [2]BIAN Gen-qing, [3]ZHU Xu-dong

[1, First Author] School of Management, Xi'an University of Architecture and Technology,
[*2, Corresponding Author] School of Information and Control Engineering, Xi'an University of Architecture and Technology,
[3] Schools of Information and Control Engineering, Xi'an University of Architecture and Technology,

Abstract

In **order to solve those issues including limited storage capacity, high cost of storage and fault recovery in traditional HDFS, cloud storage can effectively solve these problems by using virtual resources of the IaaS based on HDFS. But it cannot assure cloud storage to utilize virtual resources more effectively. In order to solve these problems, the paper proposes a elastic cloud storage framework based on HDFS, and introduces the thought of virtual resources management into the framework, and proposes a elastic management strategy of virtual resource allocation and scheduling based on this framework. The simulation experiment shows cloud storage can effectively improve the efficiency in the use of virtual resources.**

Keywords: HDFS; Elastic Cloud Storage; Virtual Resource; Resource Allocation and Scheduling; feedback control theory.

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I Introduce

With the development of Web2.0 technology, especially the popularity of social network and popular, the traditional storage technologies (network Storage or distributed storage) are difficult to meet the demand of their vast amounts of unstructured data storage[1]. So more and more commercial websites began to use cloud storage architecture based on HDFS, such as Google, Amaze, Facebook, etc., the development is gathering momentum. Design ideas of HDFS-based cloud storage derived from the virtual cluster computing, which is expanded from a single virtual storage servers to a virtual storage server cluster (ie: Hadoop virtual cluster). Hadoop virtual cluster can be combined with multiple virtual storage servers, just as a storage server which has a great computing power and high-throughput provides users with a transparent access interface[2]. However, the existing cloud storage has certain limitations in study and implementation, which concerned for high-throughput and high reliability excessively, and ignored the cloud storage's actual use rate on virtual resource, thus it seriously affects the cloud storage application and popularization. Cloud storage for load-handling capability and disturbance switching capability is important, but we should be even more concerned about the actual efficiency of cloud storage to the virtual resources. Therefore, through introducing the thought of virtual resource management, this article proposes a kind of elastic storage architecture and elastic management strategy of virtual resources. The simulation results show that cloud storage can effectively improve the efficiency in the use of virtual resources.

II HDFS on Elastic Cloud Storage

The paper makes the virtual resource scheduling units as Slot. Slot represents the characterization of virtual resources calculation ability, which is decided by the virtual resource CPU and memory size. Set *CPU* as the unit CPU capacity, taking 1GHz; *mem* on behalf of the unit memory capacity, taking 1GB; a virtual server P_i is able to provide a number of *Slot*

$$Slot_i = \min\left\lfloor \frac{cpu_i}{cpu}, \frac{mem_i}{mem} \right\rfloor \quad (1)$$

Among them, $\lfloor \ \rfloor$ says round down, cpu_i is the CPU size of virtual server P_i, mem_i is the memory size of virtual server P_i. In a moment t, HDFS loads is $load_t$, the number of virtual server is N, then available virtual resources:

$$Slot_{total} = \sum_{i=1}^{N} Slot_i \qquad (2)$$

And HDFS virtual resource use rate:

$$u = \frac{load_t}{Slot_{total}} = \frac{load_t}{\sum_{i=1}^{N} \min\left\lfloor \frac{cpu_i}{cpu_{total}}, \frac{mem_i}{mem_{total}} \right\rfloor} \qquad (3)$$

If the HDFS virtual resource usage in an expected high and low water level, it is judged as effective resource. The problem to be solved is dynamic programming R, such that when a certain amount of $load_t$. $0 < u_{low} < u < u_{high} < 1$. Therefore, to make the HDFS schedule resource elastically according to the real-time load state and resource use rate, it must be introduced the virtual resource flexibility management strategy. Flexible management strategy should include: flexible resource allocation strategy and flexible resource scheduling strategy. But if the new resource management component, or resource scheduling strategy is added to the existing HDFS, it will not only increase the complexity of HDFS, but also increase the HDFS manager additional cost, and increase the load, thus affect the overall HDFS load capacity and stability.

This paper introduces the virtual resource management platform, and puts forward Elastic cloud storage system based on HDFS. First of all, the HDFS cluster is encapsulated into a virtual resource management platform as a service, each service instance represents a HDFS data node. The use of virtual resource management platform for service instance lifetime management to realize virtual resource management platform to the HDFS data node lifetime management, i.e., by dynamically start, stop, move a service instance, equivalent dynamic start, stop, migration of a HDFS data node; secondly, through the virtual resource management platform based on the virtual resource management capabilities for the HDFS data node provides a flexible virtual resource allocation strategy, dynamic adjustment of Hadoop virtual cluster preformed resource N size, and allows multiple HDFS shared resources; at the same time, through the encapsulation of a virtual resource scheduling service, real-time monitoring of HDFS and virtual resource load information, and according to the load information and the elastic scheduling strategy on data node, HDFS elastically scheduling. Thus achieved without affecting the existing HDFS structure and function ,to solve the resource waste and the problem of resource sharing, making use of many existing virtual resource management platform to achieve them is proposed, such as OpenNebula[3][4], Platform[5]. in order to simulation test, virtual resource management conduct ISF of Platform will be used.

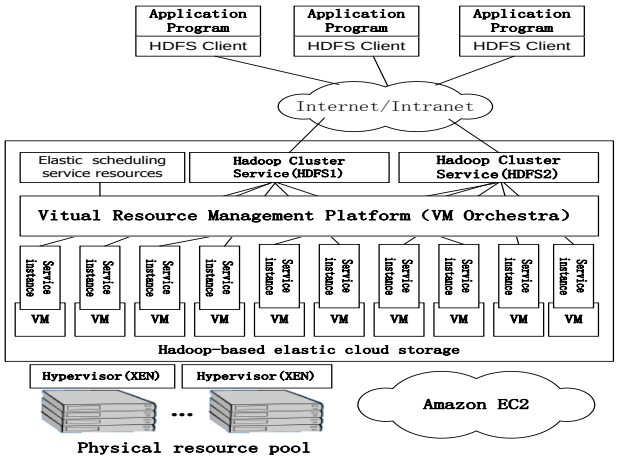

Fig 1. Elastic Cloud Storage based on HDFS

Shown in Figure 1, a elastic cloud storage based on HDFS is made up of four parts: a virtual resource, virtual resource management platform (VM Orchestra), Hadoop virtual cluster service, Hadoop virtual cluster service flexible scheduling.

Virtual resource is the carrier of Each HDFS data nodes, managed by the virtual resource

management platform. Virtual resource management platform can be deployed to run a range of services, the platform can assign a virtual resource and start one or more service instance for each service configuration.

Hadoop virtual cluster service, namely HVCS. Each HVCS service represents a particular HDFS Hadoop cluster, consisting of a configuration and one or more instances. In this paper, each instance of HVCS represents a HDFS data node, the configuration of HVCS specifies the required information when HDFS runs, and a group of flexible resource allocation strategy, namely HDFS flexible resource allocation strategy of data node.

Hadoop virtual cluster elastic scheduling service, namely HVRS. A data node is increased, removed or transferred from the HDFS cluster by HVRS through the current HDFS resources information and the load information, HDFS data node lifetime control and service scheduling interface and the provisions of flexibility principle to perform HDFS data node elastic scheduling. HVCS resource usage was obtained by the interface which is provided by the virtual resource management platform, and the HDFS load information is provided by HDFS.

III Virtual Resource Elastic Management Strategy of Elastic Cloud Storage

Virtual resource elastic management strategy of elastic cloud storage includes 2 parts: flexible resource allocation strategy and flexible resource scheduling strategy. Flexible resource allocation strategy, used to specify a set of the virtual resources for HDFS to ensure the elastic scheduling object available; the elastic scheduling strategy, elastically schedules HDFS data node through the usage of virtual resource, so as to effectively use the virtual resource.

IV Flexible Allocation Strategy on Virtual Resource

Elastic cloud storage virtual resource allocation strategy, consists of reservation strategy, sharing strategy, borrowing and lending strategy, recycling strategies. Reservation and sharing strategy provides a group of static exclusive and shared resources belonging to HCS. Reservation policy allows directly to HCS allocation reserved resources, regardless of the HCS can be used or not be used, even if HCS load is small; and sharing strategy provides shared resources for HCS, including 2 parts: shared resource belonging to HCS and overload using shared resource. Shared resource does not immediately distribute HCS resource, HCS can use resource according to the configuration of the sharing proportion only HCS has more demand, which requires more virtual nodes, and reserve resources has been exhausted; when reserved resources and sharing resources still cannot meet the demand of HCS virtual node, sharing strategy allows HCS to use other HCS free sharing resources. Borrowing and lending strategy are used for HCS to reserve resources sharing, this strategy will take effect only when shared resource has overload. By borrowing, lending the idle reserved resource, HCS can effectively use the free reserved resources in the Hadoop cluster, which effectively improves the environment resources use rate. Recycling strategy used to recycle HCS idle resources which is required sharing or borrowing out, support HCS in its spare time, and because of increasing load need more virtual node, the others can use the resources which belongs to HCS. The research results found that, after introducing the virtual resource allocation strategy, compared with the conventional HDFS fixed using a group of the allocation of resources, cloud storage on HDFS available resources are dynamic regulated according to load state.

3.2 Virtual Resource Elastic Scheduling Strategy

For every HDFS, the data node elastic scheduling strategy is composed of a three tuple structure P(S, A, R), wherein S is a sample space (Sampling), A for the action space of implementation (Actions), R (Rule) represents scheduling rules.

S represents sampling space, which consists of the virtual node load information $\{u(l(h_i))\}_{i=1}^{N}$, wherein *i* represents a virtual node, h_i represents the virtual node load capacity, $l(h_i)$ represents a virtual node load, $u(l(h_i))$ represents virtual node resource consumption. Then

$$S = \{S(h_i) \mid \{u(l(h_i)) \mid 1 \le i \le N\}\} \quad (4)$$

A said elastic scheduling execution action set, $A = (A_{over}, A_{wasted})$, wherein A_{over} represents for resource use overload handling action, A_{wasted} represents waste treatment action.

By (3) type R knowledge, scheduling rules are defined as follows:

* if the current HDFS in the resources utilization rate u higher than u_{high}, judged as resource usage overload, HCRS will perform the action A_{over} on the HDFS data node overload operation, namely: if $u > u_{high}$, then A_{over}.

* if the current HDFS resource using rate u is lower than u_{low}, it is judged to exist HDFS waste of resources, HCRS will perform A_{wasted}, HDFS node waste processing, namely: if $u < u_{low}$, then A_{wasted}.

The elastic scheduling is the process of tracking HDFS load information $\{l(h_i)\}_{i=1}^{N}$, based on the scheduling rules R, it schedules and controls timely HDFS's $Slot_{total}$, and realization of virtual resource is dispatching. In order to realize virtual resource automated flexible scheduling, introduced into the classical feedback control theory [6][7], in modeling HDFS, the relations of load information $L = \{l(h_i)\}_{i=1}^{N}$ and $Slot_{total}$, i.e.:

$$L(t) = s_1 L(t-1) + r_1 Slot_{total}(t-1) + r_2 Slot_{total}(t-2) \quad (5)$$

The model parameters s_1, r_1 and r_2, which can use regression minimum variance (Recursive Least-Squares, RLS) method assessment. In order to realize the flexible control based on this model, the equation (5) is transformed the control equation (6):

$$Slot_{total}(t) = \frac{1}{r_1} L_{ref} - \frac{s_1}{r_1} L(t) - \frac{r_2}{r_1} Slot_{total}(t-1) \quad (6)$$

Where in $L_{ref} = L(t+1)$, namely: the next time step expected HDFS load information.

The scheduling rule R is introduced to the control equation (6), which can get elastic control equation (7):

$$Slot_{total}(t) = \begin{cases} \frac{1}{r_1} L_{high} - \frac{s_1}{r_1} L(t) - \frac{r_2}{r_1} Slot_{total}(t-1) & if\ L_{high} < L(t) \\ \frac{1}{r_1} L_{low} - \frac{s_1}{r_1} L(t) - \frac{r_2}{r_1} Slot_{total}(t-1) & if\ L_{low} > L(t) \\ Slot_{total}(t-1) & otherwise \end{cases}$$

Namely: the HSC can work only when the $L_{high} < L(t)$ (higher than supply) or $L_{low} > L(t)$ (less supply), and set new $Slot_{total}(t)$, namely the executive A_{over} or A_{wasted}.

V Simulation test

Virtual resource elastic management strategies are tested, specific methods are as follows: virtual resource management platform: using virtual resource management product ISF of Platform , including 8 adjustable virtual resource Slots; and HDFS1 cluster contains 2 slots reserved resources and 1 slots of shared resources; at the same time HDFS2 cluster contains 1 slots resource

reservation and 1 slots of shared resources; load sampling through the use of CPU rate measurement, high water level u_{high} and low water level u_{low} is set to 85%, 40%; A_{over} to increase a slots, A_{wasted} to remove a slots; HDFS testing tools as HDFS Bench. Testing server test tool over a period of time, respectively for 2 HDFS cluster time tested, through the observation of 2 virtual cluster with load change for virtual resources (slots) usage. The test results as shown in figure 2.

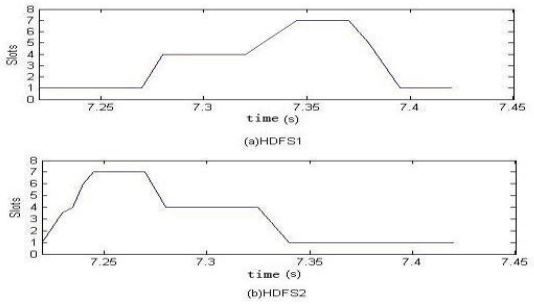

Fig 2. Simulation Result

The results show that, when HDFS1 loading amount is small, it uses only one slots, while the remainder of the resource is the part to high load HDFS2 ;with the increasing of HDFS1 loading amount, shared slots used by HDFS2 and borrowing slots will gradually returned to the HDFS1, then their maximum load using slots; With the HDFS2 loading amount gradually decreased, HDFS2 gradually reduced the use of slots, thus released slots are gradually used by the full load of HDFS1; through the use of slots sharing and borrowing from HDFS2, which gradually reduces load. Along with its load reduction, HDFS2 gradually reduces the use of slots, and tends to smooth.

VI Conclusion

Through studying of the existing HDFS constructing methods and the data node controlling mode, what makes the utilization rate of HDFS for the system resource low is the problems that the waste of resource usage and the difficulties to share resources among multiple HDFS, and the problems and difficulties are caused by the lack of flexible resource management pattern. Against this problem, this paper proposes elastic cloud storage framework based on the HDFS, and puts forward HDFS data node flexible resource allocation strategy and elastic scheduling strategy according to its characteristic. The simulation experiment shows that elastic management strategy can improve HDFS existing problems, and effectively improve the efficiency in the use of virtual resource.

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