# Resource Management Model of Data Storage Systems Oriented on Cloud Computing

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**Abstract**

This article represents a resource management model of data storage systems oriented on Cloud Computing. The model presents a single interface providing a user with an optimal resource set on the basis of the specified requirements.

## I. INTRODUCTION

At the present time one of IT areas, called Cloud Computing (CC), is being achieving a peak of it's evolution. It caused by evolution of support technologies like internet, telecommunications, data store systems, information protection systems and integrated platforms - they became so mature, that can provide reliable foundation for global information systems building and on the other hand are able to guarantee increasing needs in reliability, mobility and efficiency of information infrastructure.

The quantity of Cloud providers is increasing. At the same time the quantity of the interfaces given by providers for access to resources of the cloud is growing as well. In spite of the accessibility of open interfaces, there is no possibility to get the resources from various Cloud using the uniform interface of interaction. There was an idea to create a possibility of the unified access – a certain interface to Cloud resources which would help all suppliers to provide the resources with the minimum risk and guaranteed stability. It would allow clients to move stacks of appendices from one cloud to another, avoiding isolation and thus to cut down expenses.

Specificity of using data store systems for CC differs from both traditional server systems and data centers. It means, that disk capacity in CC systems is provided on call for some time and then returned. Required data store reliability, energy consumption, data repair speed in case of a crash, access rate and some other parameters are main efficiency characteristics of such systems.

The article presents a resource management model of data storage systems which main target is ensuring effective virtual resources forming and providing an access to them from any terminal. The direct clusters interaction both between each other and with virtual resources will be described further. The clusters consist of physical hosts. The developed model advantage is the possibility to provide a single resources access interface which ensures the required Q-factors.

## II. PROBLEM DEFINITION

In this article the main object of consideration is a cloud structure allowing user to retrieve access to the virtual resources on demand. Let us say the user into the external environment needs to retrieve resources with pre-defined quality parameters and the cost not more than the pre-defined one. The task consists in the single interface description which is rendered by a resource access cloud structure.

## III. Resource Management Model Description

It is considered that the term "cloud" came from traditional graphic depiction of the World Wide Web as a small cloud. Such a picture is used to demonstrate a network topology that has an Internet segment [2]. Consequently a cloud can be imagined as a set of different types objects connected with each other and forming an arbitrary topology.

An object can consist of one or several nodes. Cloud structure is fractal because both separate nodes and embedded clouds can be considered as cloud elements.

Such a structure is presented graphically in the fig.1:

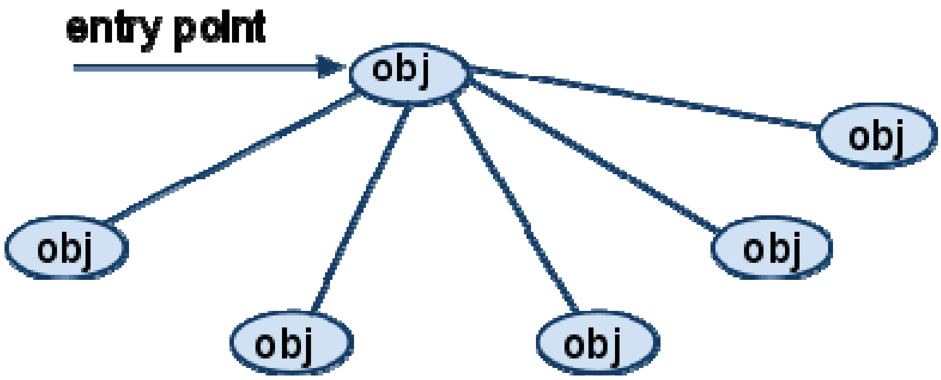


Fig.1. Concept structure

Representing a cloud as some objects with identical characteristics and the interface of access would allow us to abstract from the internal device of these objects and represent each of them as a black box. The user does not have necessity to think of how the resource with certain quality characteristics has been provided. What is important is the fact of the resource allocation.

In order to have an opportunity to provide a unified access interface, a special part for interaction both with a user and other objects should be detached. Let us call it a resource manager (Cloud Manager).

The resource manager (CM) provides a user with 3 interfaces of object resources retrieving:

1. Block (block resources provision) Blocked resource presentation. Disk emulation is used and requests are executed through, for instance, iSCSI protocol.
2. Object (DB or BLOB) Resource is provided as an object.
3. File (NFS, CIFS). Resourced are presented as a file system based on POSIX standards.

The resource manager gives access to operations targeted at resources retrieving with certain quality rates. The operations can be split into the following groups:

1. Quick access to resources.
2. Operations for providing reliability.
3. Quick information recovery.
4. Energy consumption reduction (E) targeted at the cost optimization.

Cloud Manager has necessary means of resource management which usually consist of the processor with enough memory and the built-in operating system. CM uses the same general interfaces of block level as usual IDE / SCSI disks, representing the enclosed composite objects as virtual disks.

The virtual disk is the generalized abstraction of the data storage device. He behaves as an usual block device, but has no corresponding physical disk. Instead, it is connected to existing block devices. Connection of the virtual disk means that all input-output inquiries will be directed to a virtual disk which will redirect them to the basic devices.

The concept of virtual disks allows to support a wide range of diverse platforms, and also gives the chance to reuse the existing file systems and technology of operating systems. Cloud Manager can be constructed on the basis of existing systems with little changes in OS. Herein, the operations of file system over usual files will be kept.

CM connects the service information provided to the user with input/conclusion operations via the virtual address block of cluster. The virtual address block is a block of addresses outside of possibilities of physical cluster. The idea of usage of virtual address blocks is based on the following observation: as a rule, the potential of block devices is much less than the maximum value which the operating system can support. Thus, it is possible to use the additional addresses of blocks outside of capacity of physical cluster as virtual addresses of blocks [5].

Common user and cloud structure interconnection scheme is presented in fig. 2.

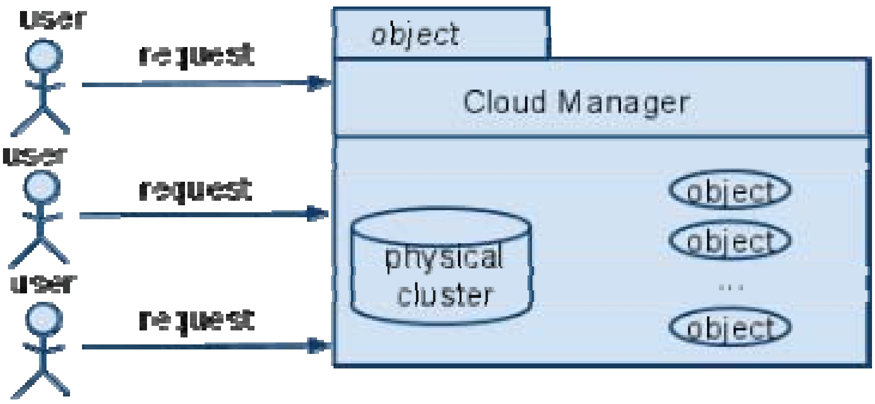


Fig. 2. Structure interconnection scheme

The model consists of two main entities:

1. U — a user who need to be provided with the resources with the guaranteed quality.
2. Cloud — objects including CM and managed resources. These resources can be formed by a certain cluster or just the same composite object.

When the user U requests the particular resource, he needs certain disk capacity and certain quality rates such as resource provision speed S, reliability R and recovery time $T_r$. Another important quality rate is resource provision cost.

The main task of the CM is the optimization of cost function to provide resources with given characteristics $P = f(V, S, R, T_r, E)$. The parameters of the optimization function are just those indicators of quality which the user needs.

Given: n — nodes count in the cluster, m - nested clouds count. So, let's build an optimization function for distribution data storage in heterogeneous environment:

1. The volume provided by object $V = \sum_{k=0}^{m}\sum_{i=0}^{n} V_i^k - O_\upsilon(V_u)$, where $V_i^0 \in R^+$ — volume of a single physical host in the cluster; $V_i^k \in [R^+, R^+]$, $k > 0$ — range of volumes for all objects belong to the embedded cloud; $O_\upsilon$ — overhead caused by an information distribution; $V_u$ — use-requested resources.

2. The speed resource allocation $S = \sum_{k=0}^{m}\left(\frac{\sum_{i=1}^{n} V_i^k \times S_i^k}{V_k} + S_k\right)$, $S_i^k \le S_{\max}$, where $S_i^0 \in R^+$ — access speed to the information of a single physical node (i) in the cluster; $S_i^k \in [R^+, R^+]$, $k > 0$ — range of velocities for all objects belong to the nested cloud; $S_K$ — access speed to the embedded cloud or physical cluster; $S_{\max}$ — maximum object's speed.

3. Reliability of resource allocation $R = 1 - \prod_{k=0}^{m}\prod_{i=0}^{n}(1 - R_i^k)$, where $0 \le R_i^k \le 1$ — probability of failure of a single physical node (i) in a cluster (k).

4. The data recovery time $T_r = \max\{T_{ri}^k\}$, where $T_{ri}^k \in R^+$ — recovery time of a single physical node (i) in a cluster (k). Recovery time is especially important at the organization of business processes where stability of system can depend on the refusal of data allocation.

5. Energy consumed by the object $E = \sum_{k=0}^{m}\sum_{i=0}^{n} E_i^k - O_\varepsilon$, where $E_i^k \in R^+$ — energy consumption of taken separately physical node in the cluster belong to both main and embedded clouds. $O_\varepsilon$ — benefit from using algorithms for power management optimization. Energy is a value that influences basically only on the cost of resources allocation.

The main task of the model is reception of the uniform reliable interface of resources allocation by creation the Cloud Manager. The task of Cloud Manager is to choose the set of nodes in a cloud (each of which has characteristics $V$, $S$, $T_r$, $R$, $E$) which can meet requirements of the user $V_u$, $S_u$, $T_{ru}$, $R_u$, $E_u$.

This problem can be reduced to a multidimensional knapsack problem [1]:
There are n hosts, with weights:
$[V_1,\ldots,V_n] \in N$ — volume;
$[S_1,\ldots,S_n] \in N$ — speed;
$[T_{r1},\ldots,T_{rn}] \in N$ — response time;
$[R_1,\ldots,R_n] \in N$ — reliability;
$[E_1,\ldots,E_n] \in N$ — energy;
and utilization cost $[p_1,\ldots,p_n] \in N$;
and user requirements $V_u$, $S_u$, $T_{ru}$, $R_u$, $E_u$.
The challenge is to find a set of nodes that the volume set is not less than the amount requested by user, the access speed is not less than required, provide the necessary response time, reliability and energy consumption. $V \ge V_u, S \ge S_u, T_r \le T_{ru}, R \le R_u, E \le E_u, P \to \min$.

In addition, problems of optimal decision search appear $O_\upsilon(V_u)$. In other words, one of main goals is to find an optimal algorithm of disk resources management (algorithms of information distribution and duplication). The other goal is to find an optimal algorithm of energy management $O_\varepsilon$.

In case when it is needed to manage huge amounts of data with different requirements, metadata can help to express such requirements in such a way that cloud managers could differentiate their processing in order to meet user requirements. In case of using mobile storage technology, it is needed to standardize metadata witch will be interpreted by a cloud manager like resource characteristics. Quality level, user constraints, geographical and network position should be included into the standard. Using of metadata will lead to increasing of reliability level and even device, storing required resource, damaged, it is possible to find the backup of it after analysis of metadata stored on other devices.

## IV. CONCLUSION

High quality and high resource availability are main requirements, witch user needs from Cloud-providers. Fractal resource management model for data store systems is presented. Some of it's main characteristics are formalized. The unified access interface provided by Cloud Manager will give an opportunity to connect clouds with each other and, thus, get unified access to all clouds from all cloud-providers.

Future model evolution suggests development of disk resources management algorithms including disc memory reservation procedures, power supply management for energy consumption minimization, information distribution and duplication algorithms for the effective data access provision from any access point.

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