Development of the Model of Dynamic Storage Distribution in Data Processing Centers

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***Abstract*—The paper reviews an optimal distribution of storage resources among the users in data processing centers. Stochastic model of the dynamic distribution of storage resources is proposed. The model ensures the use of storage resources without wasting.**

Keywords*—*data processing center; cloud computing; storage capacity; Markov process; stochastic model.

I. INTRODUCTION

Nowadays, computing and storage resources of personal computers are not sufficient for the solution of complex problems requiring big computing and storage resources such as real time modeling of physical and chemical processes, nuclear reactions, global atmospheric processes, economic development in various fields of science, as well as Cryptography, Geology, development of new drugs. Supercomputers with high performance computing and big storage are widely used in the above-mentioned issues [1]. As a strategic product, the high price of supercomputers reduces its availability for many countries to be used in scientific and technical research. However, these countries have demand for big computing resources. On the other hand, computing and storage resources of the data processing centers connected to the computer networks are not used effectively. Researches show, that only 60-70% of computing and storage resources of computers manufactured by giant companies (Intel, IBM, Google, etc.) are used effectively [2]. In this case, remaining unused computing and storage resources of data processing centers can be used to solve complex problems. Applying remote access to the data processing centers in daily practice with the help of high speed communication channels open up new possibilities for the users. Now, the quantitative increase of opportunities of users to get information caused qualitative change in the organizational principles of distributed computing systems in the networks.

At present, research is conducted out for an effective use of computing and storage resources of data processing centers with the help of Cloud Computing. Such systems with big computing and storage resources are based on computer networks, provided with high-speed communication channels. Cloud Computing enables organizations to use computing and storage resources of data processing centers more efficiently. The concept of Cloud Computing provides the development and utilization of infrastructure and software of computer technology in the network. With the help of this technology, the user data is stored and mined on Cloud Computing servers, at the same time, the results are viewed through browsers [3]. Cloud Computing allows the users to access powerful computing and storage resources, and at the same time, the user is not interested where these resources are located and installed. The paper is dedicated to the optimal distribution of storage resources among the users. The proposed model allows the data processing center to attract more users providing optimal distribution of available storage and system resources among the users.

The content of the article is organized as follows:

- State of the memory use in data center was set to change as Markov process;
- The characteristics of Markov process of the memory usage change were identified;
- Recommendations were given for the use of obtained results.

II. DEVELOPING THE MODEL OF DYNAMIC STORAGE DISTRIBUTION IN DATA PROCESSING CENTERS

Let us analyze the process of dynamic storage distribution among the users of the systems where Hypervisors are applied. The process of dynamic storage distribution is modeled as Markov process [4]-[7]. Let us suppose that M is the number of users specified in advance and suggesting storage need. In this case, m-th user ($m \in [1, M]$) uses Vm amount of memory. Thus, an amount of memory required by users is as follows:

$$V_1, V_2, \dots, V_M. \quad (1)$$

If V_t denotes storage volume that is used instantly at any t time

$$V_{tmin} = 0, V_{tmax} = \sum_{m=1}^{M} V_m. \quad (2)$$

Nevertheless, in practice,

$V_{tmax} = \sum_{m=1}^{M} V_m$ is almost impossible. In the peak of storage use it is practically as follows:

$$V_{peak} \leq 0{,}7 * V_{tmax}. \quad (3)$$

This may lead to attracting additional users.

Each storage user can apply for storage at random moments of time, regardless of its physical identity and functionality. Therefore, the process of memory use is determined by a random *Vt* storage volume used instantly at any time *t*. In this case, state space of the process is defined by the storage of different capacity in use. The process of transition from one state to another does not depend on the transition path. This transition depends on the current state, and it is one of the signs of Markov process. It is sometimes called the process without memory.

The second key feature of Markov processes the finite number of states. In our case, the required number of different volumes (states) is finite. Thus, M number of users can apply for storage in a short time interval (time instant) 0,1,2,... . Storage capacity defining the process state depends on these combinations. Obviously, *n* number of *M* users can be choosen from $C_M^n = \frac{M!}{n!\,(M-n)\,!}$ methods. That is, different combinations C_M^n with *n* number of userscan be set up from *M* number of users. If n ∈[0; M] the number of all possible combinations can be as follows:

$$K = C_M^0 + C_M^1 + \dots + C_M^n + \dots + C_M^M \quad (4)$$

According to Newton binominal [8]-[9]:

$$\text{As} (1+1)^M = C_M^0 + C_M^1 + \dots + C_M^M, \quad (5)$$

$$K = C_M^0 + C_M^1 + \dots + C_M^M = (1+1)^M = 2^M. \quad (6)$$

In other words, the number of possible different states are $K = 2^M$, which is finite. Thus, Markov process is covered in this state.

So the model of the need for storage in the Data Center by M number of users is developed as in Markov process. The process parameters are defined as follows:

1. $E_1, E_2, \dots, E_K$ - state set.

As it is mentioned above, this set is finite and can be defined as $K=2^M$. Each state corresponds to regular order of storage volumes which can be required in different combinations.

2. Stochastic transition matrix**.** The matrix for continuous-time processes is an intensity matrix of the transition from one state to another. Intensity of transition from E_i state to E_j can be denoted by g_{ij}.

$$G = \begin{pmatrix} g_{11} & \cdots & g_{1K} \\ \vdots & \ddots & \vdots \\ g_{K1} & \cdots & g_{KK} \end{pmatrix} \quad (7)$$

3. Probability vector is the key characteristics of the modeled process. Let $P_t = \{p_1^{(t)}, p_2^{(t)}, \dots, p_K^{(t)}\}$. This vector gives complete information about the process at any time t: where $0 \le p_i^{(t)} \le 1$, $\sum_{i=1}^K p_i^{(t)} = 1$ states are covered.

In continuous-time Markov processes, the following system is used to calculate these probabilities:

$$\begin{cases} \frac{dp_j^{(t)}}{dt} = \sum_{i=1}^K p_i^{(t)} * g_{ij} \\ p_j^{(0)} = p_j^{(0)} \\ \dots \\ \sum_{i=1}^K p_i = 1 \end{cases} \quad (8)$$

This system can be solved by approximate methods. If the process has ergodic features, it is a system of algebraic equations, which has only one solution.

$$\begin{cases} \sum_{i=1}^K p_i g_{i1} = 0 \\ \sum_{i=1}^K p_i g_{i2} = 0 \\ \dots \\ \sum_{i=1}^K p_i g_{iK} = 0 \\ \sum_{i=1}^K p_i = 1 \end{cases} \quad (9)$$

As the ergodic process shifts to stationary mode, it does not depend on time and it shifts to

$$P(t) = (p_1^{(t)}, p_2^{(t)}, \dots, p_K^{(t)}) = (p_1, p_2, \dots, p_K) = P \quad (10)$$

The equation (10) is the vector of transition probabilities of the process from the i-th state into another. This vector provides the probable distribution of the condition of the process in which it will be in the future.

If $j \in [1, K-N]$ the probability of the calls to the computing resources of the users of $i \in [j+1, j+N]$ number is calculated as follows: $\sum_{i \in [j+1, j+N]} p_i$. This sets the condition of attracting new users as well.

III. CONCLUSION

The paper reviews an optimal distribution of storage resources among the users in data processing centers. The model of the dynamic distribution of storage resources is proposed. The model provides that the storage resources allocated for any purpose hold the space in the system as much as they are used. Thus, resources are allocated as much as they are used without wasting. This is beneficial for both cloud provider and the user. Accordingly, the user does not pay for reserved resource, but only for the actual resource use, and the provider reduces unnecessary purchase and installation of additional equipment's. Furthermore, it can be able to offer the same service for lower price, which leads to greater user involvement in this type of services.

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