http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 13 (11): 1908-1911, 2014
ISSN 1812-5638 / DOI: 10.3923/itj.2014.1908.1911

Parameter Analysis Model of Distributed File System Based on Improved Analytic Hierarchy Process

Tiezhu Zhao and Huaqiang Yuan
Engineering and Technology Institute, Dongguan University of Technology,
Dongguan, Guangdong, 523808, China

Abstract: The performance of distributed file system is more and more important in the mass distributed storage system due to the continuous growth of Internet data. Appropriate performance factor selection is a critical first step in effectively analyzing and tuning the performance of distributed file system. This work systematically analyzes the performance factors of distributed file system and proposes a performance parameter analysis model based on the improved Analytic Hierarchy Process (AHP) for distributed file system. The evaluation results validate the proposed parameter analysis model and indicate that the potential important performance factors can be selected effectively by utilizing the proposed parameter analysis model.

Key words: Distributed file system, hadoop, lustre, data-intensive application

INTRODUCTION

Cloud computing is a compelling technology. Following the rapid growth of cloud computing, increasing numbers of data-intensive applications with real-time requirements are deployed in large-scale distributed storage environments (Wang *et al*., 2012). In view of the dynamic demand of cloud applications, cloud computing should be has good scalability, can dynamically extend cloud scale. Industry and academia are generally believed that the distributed file system is an important technology to build the cloud data center (Hsiao *et al*., 2013).

Distributed file system is the key part of any complete massively distributed computing environment (Cheng and Wang, 2012). The performance of distributed file system directly affects the efficiency of the whole distributed computing environment. Therefore, the performance of distributed file system is the key research issue. Effective storage management depends on the optimal allocation of resources and the accuracy of the storage performance models. However, one major challenge is how to choose the appropriate performance factors to model the performance of storage system.

To solve these problems, this study explores the performance factors of distributed file systems, improves the normal Analytic Hierarchy Process (AHP) and presents a parameter analysis model based on the improved AHP. The AHP was proposed in 1977 (Saaty, 1977). The AHP is a structured modeling technique. It decomposes the complex decision problem into a series of sub-problems (Ohnishi *et al*., 2011). This study applies the improved AHP to analyze and filter the performance factors of distributed file system.

PERFORMANCE FACTORS AND DISTRIBUTION

Decades of storage systems research have identified numerous workload characteristics that can be used to describe I/O. Common among them are measures of the read/write ratio, I/O request size, spatial locality, temporal locality and concurrency (Wang and Xu, 2008). Other complex characteristics include the inter-arrival time of I/O bursts, the phasing of different I/O streams, spatio-temporal correlations etc. Resource utilization is also an important aspect of performance factors (Zhao *et al*., 2010). Table 1 describes the performance factors of distributed file system systematically.

A variety of metrics are used to evaluate storage systems, including performance, capacity, availability, reliability, and cost. Although, the performance is not the only measure of success and new storage system will certainly be judged by its speed. Three performance metrics are commonly used to quantify storage system performance, namely, I/O bandwidth (data transfer rate), throughput (I/O request completion rate) and latency (I/O request execution time).

Corresponding Author: Tiezhu Zhao, Engineering and Technology Institute, Dongguan University of Technology, Dongguan, Guangdong, 523808, China

Table 1: Performance component and factor description

Component	Performance factor description
Metadata server	No. of servers, read/write cache, stripe policy, No. of threads, CPU, memory, type of journal, etc.
Data server	Type of journal, type of disks, stripe pattern, No. of servers, No. of threads, I/O bandwidth, read/write cache, etc.
Client	Read/write cache, read/write pattern, characteristics of I/O request, etc.
Network	(aggregated) I/O bandwidth, (aggregated) network bandwidth, type of storage connection, etc.

PARAMETER ANALYSIS MODEL

Here, the performance analysis model based on the improved AHP was proposed.

Construct performance factor hierarchy: The performance factor selection problem under consideration can be represented in a hierarchical structure. The highest level (Goal layer) of the hierarchy consists of a unique element that is the overall objective, namely selecting the more informative factor subsets. At the lower levels (Criteria layer), there are multiple elements (i.e., elements within a single level) with relationships among elements of the adjacent higher level to be considered. The elements are evaluated using subjective judgments of a decision maker based on experience or experimental results. Elements that lie at the upper level are called parent elements while those that lie at lower level are called child elements. Alternative elements are put at the lowest level (Alternative layer) of the hierarchy.

Construct comparison matrix: The importance of the element can be quantified by 9 Scaling Law (Hariri *et al.*, 1999) (Table 2).

The relative importance index, which indicates intensities of importance from element i to j, is denoted as:

$$a_{ij} = \frac{x_i}{x_j}$$

where, x_i and x_j is the scale of element i and j, respectively.

The comparison matrix A can be constructed as:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}$$

Calculate weight vector: The weights of the elements, which represent the grade of importance among each element, are calculated from the comparison matrix. It can be calculated by:

$$AW = \lambda_{max} W$$

where, the eigenvector λ_{max} corresponds to the maximum positive eigenvalue of the comparison matrix A. W is regularization eigenvector. In fact, the eigenvector is very difficult to calculate. The square-root law is applied to calculate its approximation:

Table 2: Quantitative scale of performance factors

Scale	Description
1	With equal importance
3	The prior is a little bit more important
5	The prior is obviously more important
7	The prior is highly more important
9	The prior is extremely more important
2,4,6,8	The internal values between the above adjunct two values

$$M_i = \prod_{j=1}^{n} W_{ij}$$

$$\overline{W_i} = \sqrt[n]{M_i}$$

Let e_i (i = 1, 2, ..., n) is the weight of x_i (i = 1, 2, ..., n), W_i can be normalized as:

$$W_i = e_i \Big/ \sum_{j=1}^{m} e_j$$

The weight vector W can be constructed by:

$$W = (W_1, W_2, ..., W_m)$$

Consistency check: Since the components of the comparison matrix are obtained by comparing between two elements, coherent consistency is not guaranteed. The consistency of the comparison matrix A is measured by the following Consistency Index (CI):

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where, n is the order of matrix A and λ_{max} is its maximum eigenvalue.

It should be noted that $CI \geq 0$ holds. If the value of CI becomes smaller, then the degree of consistency becomes higher and vice versa.

The consistency ratio (CR) is defined as:

$$CR = \frac{CI}{RI}$$

where, RI is the random consistency index (Liu and Wang, 2007), as shown in Table 3.

The comparison matrix is consistent if the following inequality holds:

Table 3: RI value description

Rank	1	2	3	4	5
RI	0.00	0.00	0.58	0.90	1.12
Rank	6	7	8	9	10
RI	1.24	1.32	1.41	1.45	1.49

$$CR<0.1$$

Otherwise, the comparison matrix A should be modified until it can meet the consistency condition.

Comprehensive evaluation order: Assuming the kth layer consists of n_k elements and the (k-1)th layer has n_{k-1} elements, the weight mapping vector of the kth layer is defined as:

$$M_j^{(k)} = (W_{1j}^{(k)}, W_{2j}^{(k)}, ..., W_{n_k j}^{(k)})$$

where, $M_j^{(k)}$ is constructed by weight vectors from all elements of the kth layer to jth element of the (k-1)th layer:

$$M^{(k)} = (M_1^{(k)}, M_2^{(k)}, ..., M_{n_{k-1}}^{(k)})$$

where, $M^{(k)}$, a $n_k \times n_{k-1}$ weight mapping matrix, is constructed by weight vectors from all elements of the kth layer to all elements of the (k-1)th layer.

Let h is the number of the criteria layers. $W^{(h)}$ can be calculated by the following iterative formula:

$$W^{(k)} = (W_1^{(k)}, W_2^{(k)}, ..., W_{n_k}^{(k)})^T = W^{(k-1)} \cdot M^{(k)}$$

$$W^{(h)} = W^{(1)} \cdot ... \cdot M^{(k)} \cdot M^{(k-1)} \cdot ... \cdot M^{(h)}$$

where, $W^{(l)}$ is the weight vector of the 1st layer.

EVALUATION AND ANALYSIS

Evaluation scenarios: Based on the previous study (Zhao *et al*., 2011a), this study takes Lustre file system, a distributed file system used in High Performance Computing (HPC), as the research object. This proposed approach first decomposes the performance factors of Lustre and constructs the factor hierarchical structure of Lustre, which is shown as follows:

- **Goal layer:** Select the most informative performance factor subset
- **Criteria layer:** Metadata-server related factors, data-server related factors, client related factors and network related factors
- **Alternative layer:** Type of journal, No. of threads, type of storage connection, type of disks, No. of servers

The evaluation goal is to select the most informative performance factor subset from type of journal, No. of threads, type of storage connection, type of disks and No. of servers. The factors to be considered are metadata-server related factors, data-server related factors, client related factors and network related factors.

Model analysis: According to the basic principle of the improved AHP, this approach firstly constructs comparison matrix A between Goal layer and Criteria layer. By solving the eigenvalue equation, the basic parameters are calculated as follows: The eigenvalue $\lambda_{max} = 4$, the consistency index CI = 0, the random consistency index RI = 0.58, the consistency ratio CR = 0<0.1, so this comparison matrix can meet the demand of consistency check. The normalized weight vector $W^{(l)}$ is acceptable:

$$W^{(1)} = (0.30, 0.20, 0.30, 0.20)$$

According to the above equation, the weight mapping matrix $M^{(2)}$ can be calculated as follows:

$$M^{(2)} = \begin{bmatrix} 0.13 & 0.35 & 0.72 & 0.34 & 0.41 \\ 0.51 & 0.42 & 0.31 & 0.23 & 0.15 \\ 0.34 & 0.19 & 0.16 & 0.57 & 0.50 \\ 0.23 & 0.36 & 0.32 & 0.28 & 0.53 \end{bmatrix}$$

$$W^{(2)} = W^{(1)} \cdot M^{(2)}$$

The normalized comprehensive evaluation order can be calculated as:

$$W^{(2)} = (0.14, 0.17, 0.15, 0.20, 0.34)$$

The $W^{(2)}$ indicates that the importance of performance factors is arranged as follows: No. of servers, type of disks, No. of threads, type of storage connection and type of journal. The evaluation results are in line with (Zhao *et al*., 2011b). It is believed that the evaluation result is acceptable by using the proposed parameter analysis model.

CONCLUSION

This study explores the performance factors of the distributed file system and studies the factor selection methods. This work improves the normal AHP method, and proposes a parameter analysis model of distributed file system based on the improved AHP. In order to verify the efficiency of this analysis model, an evaluation of Lustre file system is performed by using the proposed model. The evaluation result indicates our analysis model can effectively select the suitable performance factors.

ACKNOWLEDGMENTS

This study is supported by the Natural Science Foundation of Guangdong Province, China (Grant No. S2012040007746), the Scientific Research Foundation for Doctors of DGUT (Grant No. ZJ130604), the National Natural Science Foundation of China (Grant No. 61170216, 10805019, 61272200), the Planned Science and Technology Project of Jiangmen City, China (Grant No. 20120030097530).

REFERENCES

Cheng, K. and N. Wang, 2012. The feasibility research of Cloud storage based on global file system Proceedings of the 9th International Conference on Fuzzy Systems and Knowledge Discovery, May 29-31, 2012, Sichuan, pp: 2507-2511.

Hariri, S., P. Varshney, L. Zhou, V.V. Menon and S. Ghaya, 1999. A hierarchical analysis approach for high performance computing and communication applications. Proceedings of the 32nd Hawaii International Conference on System Sciences, January 1, 1999, IEEE Computer Society Washington, DC, USA., pp: 1-8.

Hsiao, H.C., H.Y. Chung, H. Shen and Y.C. Chao, 2013. Load rebalancing for distributed file systems in clouds. IEEE Trans. Parallel Distrib. Syst., 24: 951-962.

Liu, C.Y. and D.S. Wang, 2007. AHPCC: A high performance computer system evaluation model based on HPCC and analytic hierarchy process. J. Software, 18: 1039-1046.

Ohnishi, S. and T. Yamanoi and H. Imai, 2011. A weights representation for absolute measurement AHP using fuzzy sets theory. Proceedings of the 5th International Symposium on Computational Intelligence and Intelligent Informatics, September 15-17, 2011, Floriana, pp: 67-71.

Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. J. Math. Psychol., 15: 234-281.

Wang C.M., T.C. Yeh and G.F. Tseng, 2012. Provision of storage QoS in distributed file systems for Clouds. Proceedings of the 41st International Conference on Parallel Processing, September 10-13, 2012, Pittsburgh, PA., pp: 189-198.

Wang, M. and L. Xu, 2008. Characteristics analysis of aggregate workload on storage system. Proceedings of the 4th International Workshop on Storage Network Architecture and Parallel I/Os, September 24, 2008, San Diego, CA., pp: 84-89.

Zhao, T., V. March, S. Dong and S. See, 2010. Evaluation of a performance model of Lustre file system Proceedings of the 5th Annual ChinaGrid Conference, July 16-18, 2010, Guangzhou, pp: 191-196.

Zhao, T.Z., S.B. Dong, V. March and S. See, 2011a. Performance evaluation and relative predictive model of parallel file system. J. Software, 22: 2206-2221.

Zhao, T.Z., S.B. Dong, V. March and S. See, 2011b. Predicting the parallel file system performance via machine learning. J. Comput. Res. Dev., 48: 1202-1215.