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A METHOD TO ANALYSE THE QOS ATTRIBUTES WEIGHT OF CLOUD SERVICES

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Abstract: Analyzing the QoS attributes weight plays an important role in understanding and improving the quality of cloud computing systems and cloud-based applications. The objective reaction of user preferences can provide a good user experience and high quality service for the users, and plays an important role in the end to end services .Therefore, This paper presents a method to analyse the QoS attributes weight of cloud services based on fuzzy analytic hierarchy process(FAHP) . Firstly, we Summarize the current research of QoS attributes weight, and build a three-hierarchical structure model according to different QoS properties of cloud services. Secondly,we describe the detailed steps of calculating the weight of QoS based on FAHP. Finally, an case is used to verify the effectiveness of the proposed method.

Keywords: FAHP; QoS; Attribute Weight; Cloud Service

1. Introduction

The large-scale development of cloud computing and demand supply for cloud services in the terminals makes more and more people feel convenience the cloud computing provides. Cloud services have the most significant feature is to meet the individual needs of users, which is different from the network service. QoS can be divided into quantifiable criteria and non-quantifiable criteria. Researchers can measure the quantifiable criteria, however, the non-quantifiable criteria are difficult to be measured easily given the subjectivity nature of these criteria.

According to the needs of users preferences, determining the QoS attributes weight of cloud services, it is necessary to research on personalized demands of cloud services. Xiong's work builds a QoS model of replica selection in the cloud computing data center ,according to the QoS requirements of users, and this QoS proper-ty includes safety, timeliness and reliability, then proposes a QoS algorithm based on the analytic hierarchy process in literature[1]. Liu's work establishes a three-dimensional user preference model based on time, safety and reliability, through the analysis of user preference in cloud environment, and uses AHP to determine the weight of each attribute in literature[2]. Huang's work builds a evaluation system of cloud services, combining with Web service evaluation and he characteristics of cloud services, then analyse the QoS weight of cloud services based on ANP method in literature[3] .It follows that the model of QoS attributes is established firstly, then use AHP to determine the weight, and achieved good results.

However, due to the information from the user's requirements is often inaccurate, the differences and one sidedness of people's subjective understanding, the constructed judgment matrix needs to be corrected and adjusted many times in order to get the satisfactory accuracy[4]. Additional, AHP must check the consistency of the judgment matrix in every hierarchical sort and its judgment standards lack of science. Therefore, the fuzzy analytic hierarchy process(FAHP) can calculate the QoS attributes weight much more precisely. This paper's method combines the fuzzy mathematics and AHP method, which can reduce the complexity of AHP , and deal with accurate information and fuzzy information effectively. Besides, it can reduce the interference of subjective factors.

2. Three-hierarchical Structure Model of QoS

In this article, cloud services could be classified into three categories according to timeliness, reliability and scalability. The following describes the role of each category in detail.

Timeliness: Service time can be divided into process time and response time. Processing time is associated with the performance of service platform, and the response time is determined by external factors of service system, such as quality, signal transmission and network speed etc. The delay bandwidth consumption and service access are two important characteristics of cloud

service QoS attributes, because from the from the beginning to the end in the scheduling process data. Thus, the timeliness is measured by transmission delay, throughput and network band with metrics.

Reliability: The attribute assess the ability of the cloud service to keep functioning with particular level of performance over time. Some aspects of reliability are important within a cloud computing, particularly the reliability of the information that are transmitted from the service provider to the service consumers , and the reliability of the services themselves. In this section, the reliability is measured by service stability, service accuracy and reliability metrics.

Scalability: Cloud services have the characteristics of dynamic scalability, adjusting the dynamic allocation of service resources according to the quirements of users [5] .The scalability of cloud services consists of the horizontal scalability and vertical scalability services. This attributed is mainly defined for the reason is that cloud services are provide their services dynamically scalable manner and frequently virtualized resources are published as the certain services by internet. Therefore, the scalability is measured by service maintatinability, service reusability and CPU utilization metrics.

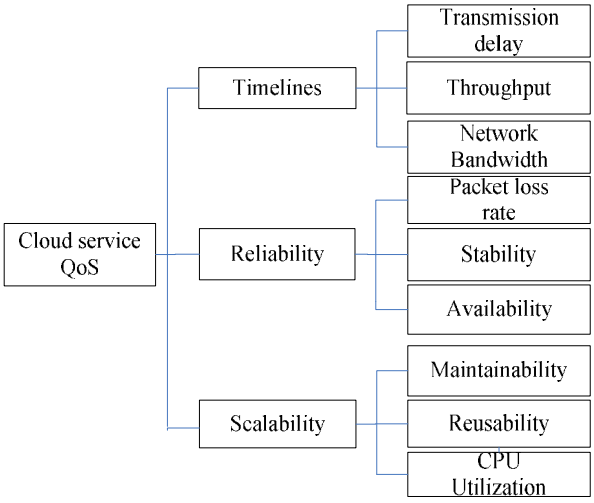

Figure 1. Three-hierarchical structure of QoS

Thinking out the practical problems of cloud services, especially in view of users with different demands for different services, a three-hierarchical structure model is built according to different pro- perties[2]. As shown in Figure 1, the first layer is decision layer which focuses on selecting an optimal personalized cloud services for user. The second layer is the criterion layer, which has three parts, respectively called timeliness, reliability and scalability. The third layer offers specific QoS attributes.

3. Calculting the Weight based on FAHP

3.1. The Definition of FAHP

FAHP reduces the amount of computation to solve the weight, meanwhile, because of the consideration of the fuzziness of attributes weight of the QoS, it can reflect the information of user preference accurately. The definition and of FAHP is described as following[6]:

Definition 1.Suppose matrix $A=(a_{ij})_{n\times n}$,if $0 \le a_{ij} \le 1$,then A is fuzzy matrix.

Definition 2. For fuzzy matrix $A=(a_{ij})_{n\times n}$,if $\forall i, j, k$, $a_{ij} = a_{ik} - a_{jk} + 0.5$, then A is a fuzzy consistent matrix.

Definition 3. For fuzzy matrix $A=(a_{ij})_{n\times n}$,if $a_{ij} + a_{ji} = 1$, then A is fuzzy complementary matrix.

3.2. Calculation Steps of FAHP

The basic steps of applying FAHP model in determining QoS attribute weights of cloud services as following:

1. Analysing user's requirements and establishing a model of three-hierarchical structure. The factors contained in the objective criteria system are divided into different levels, such as target layer, rule layer and program layer. From the three-hierarchical structure, judgment matrix is constructed through the weight of each criterion. Importance is described by relative weights a_{ij} ; it is got by comparison of element between i-th and j-th .

2. Constructing fuzzy judgment matrix. According to hierarchy structure model, we construct fuzzy judgment matrix from top layer to bottom layer. Elements of each layer are standard of the adjacent on forward level elements. Fuzzy judgment matrix is built by pair-wise comparison under 0.1-0.9 scale methods[4]. The meaning of each scale is shown in Table 1.

3. Calculating the weight vector. We can transform the fuzzy complementary matrix into fuzzy consistent matrix through the above methods, then the weight vector of each layer can be obtained.

The detailed steps as following in literature [6]:

(1) Suppose fuzzy complementary matrix $A=(a_{ij})_{n\times n}$ and calculate the summation of each row h_i as the following formula:

$$h_i = \sum_{k=1}^{n} a_{ik} \quad (1)$$

(2) Make mathematic transformation as below:

$$c_{ij} = \frac{h_i - h_j}{2(n-1)} + 0.5 \quad (2)$$

Then a fuzzy consistent matrix $C=(c_{ij})_{n\times n}$ is set up.

(3) We calculate sum of each row of C , handle it by standardization, then get the weight vector w_i , the following formula:

Table 1. $0.1 \sim 0.9$ **Scale**

Scale a_{ij}	Meaning
0.5	Comparing C_i with C_j, it is the same importance
0.6	Comparing C_i with C_j, C_i is little more importance than C_j
0.7	Comparing C_i with C_j, C_i is more importance than C_j
0.8	Comparing C_i with C_j, C_i is much more importance than C_j
0.9	Comparing C_i with C_j, C_i is very more importance than C_j
0.1,0.2,0.3,0.4	It is anti-comparison, if a_{ij} is the result of C_i compare with C_j, so $a_{ji} = 1 - a_{ij}$ is of C_j compare with C_i

$$w_i = \frac{\sum_{j=1}^{n} c_{ij} + \frac{n}{2} - 1}{n(n-1)},\ i, j = 1, 2, \cdots, n \qquad (3)$$

4. Case Study

Suppose that the user's requirements of service preference is: timeliness > reliability > scalability, thus, we can construct the fuzzy judgment matrix A, the following formula:

$$A = (A_{ij})_{3\times3} = (f(a_i, a_j))_{3\times3} = \begin{pmatrix} 0.5 & 0.6 & 0.8 \\ 0.4 & 0.5 & 0.6 \\ 0.2 & 0.4 & 0.5 \end{pmatrix} \qquad (4)$$

$x_i, i \in [1, 2, 3]$ respents for time, stability and scalability respectively in the formula (4).

The sum of each row of fuzzy judgment matrix A could be calculated by the formula $h_i = \sum_{k=1}^{n} a_{ik}$,then $h_1 = 1.9$, $h_2 = 1.5$, $h_3 = 1.1$. According to the formula $c_{ij} = \frac{h_i - h_j}{2(n-1)} + 0.5$,we can get the fuzzy consistent matrix, the result as below:

$$C = (c_{ij})_{3\times3} = \begin{pmatrix} 0.5 & 0.6 & 0.7 \\ 0.4 & 0.5 & 0.6 \\ 0.3 & 0.4 & 0.5 \end{pmatrix} \qquad (5)$$

We can calculate the weight vector W through the formula $w_i = \frac{\sum_{j=1}^{n} c_{ij} + \frac{n}{2} - 1}{n(n-1)}$, then get the vector $W = (0.383, 0.333, 0.284)^T$.

In the same way, suppose that maintainability is the highest requirements for users in the dimensions of scalability, and reusability is the higher, then CPU utilization is little higher. Therefore,we can build a fuzzy judgment matrix A_1, $x_i, i \in [1, 2, 3]$ respents for maintainability, reusability and CPU utilization respectively in the formula (6).

$$A_1 = (A_{ij})_{3\times3} = (f(a_i, a_j))_{3\times3} = \begin{pmatrix} 0.5 & 0.7 & 0.9 \\ 0.3 & 0.5 & 0.7 \\ 0.1 & 0.3 & 0.5 \end{pmatrix} \qquad (6)$$

Following the above steps, $W_1 = (0.408, 0.334, 0.258)^T$ is the weight vector of maintainability. Therefore, we can get the weight of other services preference through the analysis and calculation. Finally, we can obtain the information of the user preference for each QoS attribute.

5.Conclusion

This paper presents a approach to analyse the QoS attribute weights of cloud services based on FAHP. Building a three-hierarchical structure model according to different QoS properties of cloud services firstly, then the article describes the detailed steps of calculate the weight of QoS based on FAHP. Finally, an example is used to verify the effectiveness of the proposed approach. Since the FAHP method has dered the fuzzy information of attributes, FAHP has some advantages in the solution of the weight ,comparing with AHP. For example, there is no point in verifying the consistency of judgment matrix, thereby it eliminates the cumbersome calculation to decide the maximum eigenvalue of the matrix. Therefore, FAHP reduces the amount of computation to solve the weight, at the same time, because of the consideration of the fuzziness of attributes weight of the QoS, it can reflect the information of user preference accurately.

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