Partner selection of cloud computing federation based on Markov chains

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Abstract

Cloud computing is currently a hot in the field of information technology, and cloud computing alliance is an important direction. In order to make the league better development of cloud computing and solve the problem of selecting partners of cloud computing federation. This paper builds the structure of cloud computing federation system and evaluation indicators system of federation partner selection, and proposes a dynamic comprehensive evaluation model based on Markov Chain and Analytic Hierarchy Process, further to get exact values of evaluation for different evaluating targets in different time periods. Based on the assessment analysis and simulation results there are a reasonable selection coalition partners. The example demonstrates the feasibility and rationality of the evaluating method and builds in this paper, which would guide partner selection of cloud computing federation.

Keywords: cloud computing federation, partner selection, Markov chain, analytic hierarchy process

1 Introduction

Cloud computing, as a new IT delivery models, is a major achievement of modern information technology. And it has been recognized as the most worth waiting technological revolutions. At present, whether cloud computing service providers or the users, have begun to pay attention to cloud computing can bring about tremendous business value. In 2013, cloud computing industry have reached 100 billion RMB, it will rapidly development in the future.

With the technology of cloud computing research deeply and applied gradually mature, according to large-scale, virtualization and cloud computing technology of elastic scalability, on-demand service, low cost [1], appeared to integrate cloud computing hardware and software infrastructure providers. Network infrastructure providers, transports Uygur providers, terminal equipment manufacturers and market promotion of business and computing clouds of different subjects of commercial services in the industrial chain of resources, to provide services to the needs of users [2]. The development of the cloud computing industry alliance is the inevitable choice to meet this demand. Cloud computing is guided by the demand of the market, as the basis for cooperation with the cloud computing industry value chain alliance, specifically refers to the value chain to enterprises, research institutes, industry associations and between users, in order to realize the whole value chain value maximization, and constantly improve the strength and level of competitiveness and the members of their own, by contract the ways of complementary advantages, benefit sharing, risk sharing loose network of tissue [3].

At present, scholars research on alliance partner choice has made some achievements, the choice of the method of evaluation and optimization studies are presented with AHP (Analytic Hierarchy Process, referred to as AHP), fuzzy comprehensive evaluation method, data envelopment analysis (Data Envelopment Analysis, referred to as DEA), linear weighted method, advantages and disadvantages of distance solution method (Technique for Order Preference by Similarity to an Ideal Solution, TOPSIS) and the organic combination of the above various methods. However, these methods have shortcomings in common is the need for historical data, a larger number of [4]; two is only for a moment by the evaluation index of static state evaluation and analysis of [5], for the dynamic index for evaluating the accuracy is not high. But cloud computing has its own characteristics: cloud computing is an emerging industry, cloud computing in the various partners running time are shorter, not the existence of the state of development of decades of historical data. In addition, the alliance partners were associated with cloud computing technology, IT industry related, has the characteristics of fast speed of development, change quickly, the development of the state will change with time and the dynamic changes of [6]. Therefore, the above method is not well suited to cloud computing alliance partner selection.

To sum up, according to the characteristics of dynamic, cloud computing development present situation and the partner's uncertainty, this paper puts forward the dynamic

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comprehensive evaluation method based on Markov chain and AHP combination model. Cloud computing is proposed alliance architecture, establishing the cloud computing alliance partner selection evaluation index system, make full use of Markov chain "features no aftereffect", determined the comprehensive evaluation index weights with the AHP method, through the analysis and calculation of concrete, comprehensive evaluation that all partners of the value, provide accurate decision-making basis for the selection of alliance partners.

2 The Markov chain principle

2.1 THE DEFINITION

1907, the Russian mathematician Markov found, some systems in the process of state transition, the change of state is only related with the recent state, which has nothing to do with the long-term state. Namely the (n+1) the conversion result of the system, only depends on the nth state, this property is known as a non-aftereffect. Consistent with no effect of state transition process is known as the Markov process, the whole process of a series of Markov called Markov chain [7].

2. 2 THE STATE TRANSITION PROBABILITY MATRIX

Supposed that there are n states $S_1, S_2, ..., S_n$. The state of the system is S_i at time T_n, the system state converts to S_j at time T_{n+1}, and the transition probability is $P_{ij}(n)$. This probability is called the one step transition probability of Markov chain. Arranged the $P_{ij}(n)$ in a matrix based on some order, which named one step transition probability matrix P. Then, then the one step transition probability matrix is following.

$$P=\begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & & \vdots \\ p_{n1} & p_{n2} & \cdots & p_{nn} \end{bmatrix}. \quad (1)$$

2.3 THE STEADY STATE VECTOR

Markov chain will gradually in a stable state through a number of transformations, which is independent of the initial state. There will be the only state vector S, which is named as the steady state vector $S=[x_1, x_2, ..., x_n]$, When, x_i satisfies $0 \le x_i \le 1$, and Equation (2) is called steady state vector.

$$\begin{cases} S = SP \\ \sum_{i=1}^{n} x_i = 1 \end{cases} \quad (2)$$

2.4 THE MEMBERSHIP FUNCTION

We can obtain a steady vector with n evaluation index, then the membership matrix F is following.

$$F=[S_1, S_2, \ldots, S_n]^T \quad (3)$$

3 The proposed algorithm

3.1 THE CONSTRUCTION OF EVALUATION SYSTEM

3.1.1 The Cloud computing alliance architecture.

Cloud computing is take the market demand as the guidance, loose network organization for cooperation on the basis of the cloud computing industry value chain. The core of cloud computing Federation constitution is a cloud computing service providers, including three main categories: hardware infrastructure providers, the server, storage, network resources are encapsulated into services provided to users, e.g. Amazon EC2, IBM Blue Cloud and so on. Platform provider put the computing environment, environment of development platform, etc. as a service to the users, e.g. Windows Azure platform provided by Microsoft, Google App Engine platform from Google and so on. Software and application program is encapsulated into a "service" provided to the user by software providers, e.g. CRM (Customer Relationship Management) provided by the Salesforce.com. In addition, cloud computing alliance also includes related research institutes, all kinds of users, industry associations, etc. Please see Figure 1.

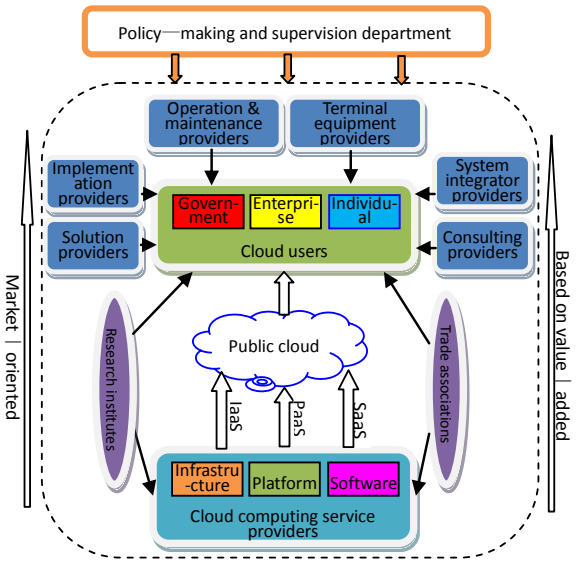

FIGURE 1 The cloud union architecture diagram

3.1.2 The Establishment of cloud computing alliance partner selection evaluation index system.

Establish a scientific evaluation index system plays a

crucial role for the subsequent coalition partners to select the results of scientific research. According to the characteristics of cloud computing alliance, refers to the literature research, survey results and expert opinion, Re.[9] concluded that the selection of evaluation indicators of the cloud computing alliance partner includes the following five aspects, quality levels, economy, technology, user-friendliness and agility [9], Please see Table 1.

TABLE 1 The index evaluation system of the cloud computing federation partner selection

Target layer	The first-level index	The second-level index
Select the best partners (a)	Quality level (b1)	Service speed (c1) Management level (c2) The degree of safety and reliability (c3)
	Economy (b2)	Cost (c4) Demand Pay (c5)
	Technical level (b3)	Versatility (c6) Resource sharing (c7) Elastic scalability (c8)
	User-friendliness (b4)	Automated management level (c9) Convenience (c10) the achieve ability to customization (c11)
	Agility (b5)	Renewal capacity (c12) Adaptability (c13)

3.2 CONSTRUCTION OF EVALUATION SYSTEM DETERMINE THE SET OF EVALUATION INDEX AND INDEX AND EVALUATION LEVEL

Assume that there n index for valuation objects, represented by $c_i(i \in 1,2,...,n)$, respectively. Then, the set of evaluation index is expressed as $C = [c_1,\ c_2,\ ...,\ c_n]$. Supposed that there are $v_i(i \in 1,2,...,m)$ evaluation levels for each evaluation index, then the set of evaluation levels is $V = [v_1,\ v_2,\ ...,\ v_m]$. The membership degree is r_{ij}, we can obtain the *i*th evaluation result of index:

$$r_i = (r_{i1},\ r_{i2},\ ...,\ r_{im}). \tag{4}$$

3.3 SYSTEM DETERMINE THE SET OF EVALUATION INDEX AND EVALUATION LEVEL

The AHP is a kind of system analysis method with combining qualitative analysis and quantitative analysis. It is also a powerful tool in analysis of multi-objective and multi criteria for complex large system. It has the characteristics of clear thinking, simple way and so on, wide range of applications, and strong system. Because this method uses more mature, the specific process no longer ago. By the calculation, the weight of each evaluation index for the cloud computing federation partner selection as shown in Table 2.

TABLE 2 Cloud Alliance Partner Selection of evaluation index system and weight

b / c	b1	b2	b3	b4	b5	(w)
	0.3629	0.1673	0.2394	0.1507	0.0798	
c1	0.3315	0.000	0.000	0.000	0.000	0.1203
c2	0.1800	0.000	0.000	0.000	0.000	0.0653
c3	0.4885	0.000	0.000	0.000	0.000	0.1773
c4	0.000	0.8333	0.000	0.000	0.000	0.1394
c5	0.000	0.1667	0.000	0.000	0.000	0.0279
c6	0.000	0.000	0.5396	0.000	0.000	0.1292
c7	0.000	0.000	0.2970	0.000	0.000	0.0711
c8	0.000	0.000	0.1634	0.000	0.000	0.0391
c9	0.000	0.000	0.000	0.2970	0.000	0.0448
c10	0.000	0.000	0.000	0.5396	0.000	0.0813
c11	0.000	0.000	0.000	0.1634	0.000	0.0246
c12	0.000	0.000	0.000	0.000	0.7500	0.0599
c13	0.000	0.000	0.000	0.000	0.2500	0.0200

$$CR = \frac{\sum_{i=1}^{5} CI(\mathrm{i})\,\mathrm{a}_i}{\sum_{i=1}^{5} RI(\mathrm{i})\,\mathrm{a}_i}$$

$$= \frac{(0.047, 0, 0.0046, 0.0046, 0)(0.3629, 0.1673, 0.2394, 0.1507, 0.0798)^T}{(0.52, 0, 0.52, 0.52, 0)(0.3629, 0.1673, 0.2394, 0.1507, 0.0798)^T}$$

$$= \frac{0.0189}{0.3916} = 0.0483 \prec 0.1$$

As can be seen from the results, the consistency of the comprehensive sort is acceptable.

4 The example analysis

We assume that the three enterprises A, B and C would be the cloud computing federation partner selection. According to a set of evaluation index system, we shall divide the assess level into five levels. Namely, best, well, general, poor and the worst. The evaluation level set of the membership vector is [0.9, 0.7, 0.5, 0.3, and 0.1]. For the three enterprises A, B and C, their recent eight quarters index scores can be assessed by the experts, such as the enterprise A, the concrete results see Table 3.

TABLE 3 A business to be evaluated scoring Fact Sheet

Evaluation	1	2	3	4	5	6	7	8
c_1	0.9	0.7	0.9	0.5	0.7	0.7	0.9	0.7
c_2	0.7	0.9	0.9	0.7	0.9	0.9	0.7	0.9
c_3	0.5	0.7	0.7	0.9	0.7	0.7	0.9	0.7
c_4	0.5	0.5	0.7	0.5	0.5	0.7	0.7	0.9
c_5	0.5	0.7	0.5	0.7	0.7	0.7	0.9	0.7
c_6	0.9	0.7	0.9	0.9	0.7	0.7	0.7	0.9
c_7	0.3	0.5	0.7	0.7	0.5	0.9	0.7	0.9
c_8	0.5	0.7	0.7	0.9	0.7	0.9	0.9	0.9
c_9	0.7	0.7	0.5	0.7	0.7	0.7	0.9	0.7
c_{10}	0.7	0.5	0.5	0.7	0.7	0.7	0.9	0.7
c_{11}	0.7	0.5	0.9	0.7	0.7	0.7	0.9	0.7
c_{12}	0.5	0.3	0.3	0.5	0.7	0.7	0.7	0.9
c_{13}	0.9	0.7	0.9	0.7	0.7	0.5	0.7	0.9

In order to reflect the phased development trend of the assessed enterprises, We use the first quarter as the starting point, the every continuous four quarters as an evaluation

stage, divides the eight quarters into five stages, and computes its phased comprehensive assessment value for each enterprise, then can compare the further development trend of three enterprises by their simulation results.

4.1 LISTS THE STATE TRANSITION MATRIX, AND OBTAINS THE STABLE VECTOR AND THE MEMERSHIP MATRIX

According to the data in Table 3 and Equation (1), such as the evaluation index c1, we obtain its transition probability matrix *P*:

$$P=\begin{bmatrix} 0 & 1/2 & 1/2 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tag{5}$$

According to the Equation (2), we obtain its stable vector $S=[0.4 \quad 0.4 \quad 0.2 \quad 0 \quad 0]$. Similarly, we can obtain the stable vectors of the other 12 evaluation indexes. According to the Equation (3), immediately, we can obtain all three indicators of membership matrix *F* of the Enterprise A.

4.2 THE COMPREHENSIVE ASSESSMENT VECTOR AND ASSESSMENT VALUE OF PARTICIPATION ENTERPRISES

For example, the 1st phase (the 1st-4th quarter) of the enterprise A, based on the vector *W*, we obtain the comprehensive evaluation vector *C*: identified membership matrix *F* and weighted

$$F_A=\begin{bmatrix} 0.4 & 0.4 & 0.2 & 0 & 0 \\ 0.67 & 0.33 & 0 & 0 & 0 \\ 0.25 & 0.5 & 0.25 & 0 & 0 \\ 0 & 0.33 & 0.67 & 0 & 0 \\ 0 & 0.5 & 0.5 & 0 & 0 \\ 0.67 & 0.33 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.25 & 0.5 & 0.25 & 0 & 0 \\ 0 & 0.67 & 0.33 & 0 & 0 \\ 0 & 0.33 & 0.67 & 0 & 0 \\ 0.34 & 0.33 & 0.33 & 0 & 0 \\ 0 & 0 & 0.33 & 0.67 & 0 \\ 0.5 & 0.5 & 0 & 0 & 0 \end{bmatrix} \tag{6}$$

$$C=W\times F=[0.2509 \quad 0.4265 \quad 0.2826 \quad 0.0401 \quad 0]$$

The assessment value *N* of the 1st-4th quarter:

$$N_A=C\times[0.9 \quad 0.7 \quad 0.5 \quad 0.3 \quad 0.1]^T=0.6777$$

With the above calculation process we can also calculate the other four stages comprehensive evaluation value for the enterprise A, and its overall assessment value of the eight quarters. The same method, we can also obtain the phased assessment value of the enterprise B and enterprise C. The concrete results as shown in Table 4.

TABLE 4 The comprehensive assessment value of three enterprises

Enterprises	Comprehensive assessment value	Evaluation period (quarter) 1st-4th	2nd-5th	3rd-6th	4th-7th	5th-8th	1st-8th
A	*N*	0.6777	0.7019	0.7058	0.7425	0.7529	0.7225
B	*N*	0.5782	0.5935	0.6211	0.5974	0.5765	0.6243
C	*N*	0.6343	0.6101	0.5932	0.5745	0.5687	0.6121

To compare horizontally assessment value of selected partners, if the assessment value is greater, it shows that the enterprise comprehensive ability is stronger, and the development trend is also better. By the comparison for the assessment value of the recent 5th-8th quarter, the enterprise A is maximum, so we should give priority to select it as a coalition partner. In addition, according to the simulation of the known data, as shown in Figure 2 and Figure 3, we can see intuitively that the enterprise A is better than the other two enterprises in the development trend, and illustrate further that the accuracy of partner selection is good by the proposed method.

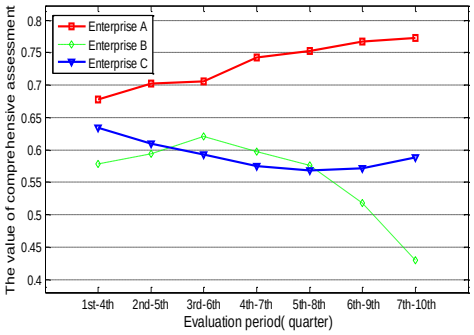

FIGURE 2 The simulation trend development status of the alternative enterprise

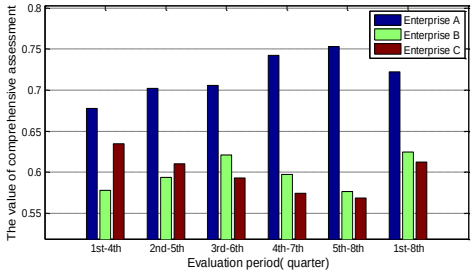

FIGURE 3 The phased development state histogram of the alternative enterprises

5 Conclusion

According to the developing station of cloud computing federation, this paper built the structure of cloud computing federation system, and proposed the general range and types of federation partners. This study built evaluation indicators system of federation partner selection according to the characteristics of cloud computing federation. Proposed a dynamic comprehensive evaluation model based on Markov Chain and Analytic Hierarchy Process according to the combination of both of the them, further to get concrete values of evaluation of the targets, and this model is more exact than other methods which can only get the range the evaluated targets belong to. And the example demonstrated the feasibility and rationality of the evaluating method built in this paper. So far, there has been little research into partner selection of cloud computing federation, there more, the evaluating method proposed in this paper would guide partner selection of cloud computing federation effectively, and it could evaluate the further development of partners continuously, reduce the risk of cooperation, and provide the decision-making basis for scientific development of cloud computing federation.

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