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AN ALGORITHM ABOUT PARTNER SELECTION PROBLEM ON CLOUD SERVICE PROVIDER BASED ON GENETIC

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ABSTRACT

Aiming at choosing suitable cloud service providers to construct a dynamic alliance and then satisfying terminal customers more efficiently, to achieve the optimal allocation of cloud services. This paper uses gray relative comprehensive evaluation model to determine the optimizing index of cloud services market. We use the multi-objective optimization model to study partner selection problem quantificational and explain the model by genetic algorithm. Selected the provider in the cloud computing market to offer the computing services, storage services, software services as a research object, extract the cost, response time, quality of service as a research indicators. Multi-objective planning was changed into a single objective by weight, the model is to be solved by genetic algorithm .Though the best fitness value, the provider find the partners with the interests of the various cloud service providers. Finally, an example show that the algorithm is rational to solve the problem about finding the best cloud service provider partners, and it is the validity of the model and algorithm.

Keywords: *Cloud Service Provider, Cloud Computing, Partners Selection, Grey Relational Analysis,Genetic Algorithm, Multi-Objective Optimization*

1. INTRODUCTION

Cloud computing is one of the popular, fashionable words nowadays. Under the form of global economic integration, the problem of how to reduce the operating costs in IT enterprise continuously growing. Cloud computing as the emerging commercial calculation model, in the model the computing service task is to be distributed in the calculation of server resource pool through the network. The storage service, computing services, software and infrastructure services is to be accessed on-demand according to various application systems on the Internet. In this context, the cloud service provider was born. Cloud service providers, just as its name implies, is the enterprise for provide service to the end user, through the new business model such as the cloud computing. As the more and more cloud service providers to enter the market, how to choose the suitable cloud service providers as the partners is to cause our attention.

The cloud service providers obtain complementary information resources, in order to highlight its advantages in the market, will form a partnership combined with their cloud service providers owned the same interests. Based on the cloud services market has its own special service mode. When select the cloud service provider partners, it need to consider its uniqueness - ability

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of rapid elasticity, on-demand self-service, broad network access, shared resource pool, measurable service. Therefore, The partner selection problem on cloud services market attract much attention from over the world. As the survivors of cloud services market in the network environment, in order to form the desired purpose of the economic cooperation, to form a good partnership, and at the same time to form the optimal allocation of resources in the cloud services market, besides there is the competitive ability of the cloud service provider and the compatibility between the cloud service partners. Above all the factors influence the criteria of the partner selection. So the difficult point of this paper is determine the reasonable optimization index and eliminate the interference in the process of information choice in the cloud services partner selection problem.

The problem of partner selection in dynamic alliance，it has attracted the interested of a few scholars to study in different areas at home and abroad. Camarinha-Matos, Cardoso [1] proposed the basic framework of the virtual enterprise partner selection and descript its function in detail. Zhan Su, Poulin d. [2], in the basis of qualitative analysis, puts forward some principles on the management of the relationships between partners. T. Srinivas and R. C. Baker [3] raise the model about the two stage partner selection process, and it is considered that the large amounts of quantitative factors and overlooked some qualitative factors in them odel. Korho - nen P [4] research in the field of information management system, he make the In-depth analysis on the partner selection of virtual enterprise. MarcoFischer, Hendrik Jahn, Tobias Teich [5] discussed the virtual enterprise partner selection problem in production networks based on the ant colony optimization theory. W H Ip, Min Huang, Yung K L, Dingwei Wang [6] studied the enterprise partner selection of the engineering project problem in the virtual environment. And the above research rarely involve the allocation problem of resources optimization in the cloud services market, the index selection about the optimized allocation of cloud services resources, and the specific optimization strategy on implementation. The overall goal of the paper is the optimized allocation rate for the cloud resources, based on the comprehensive evaluation model of grey correlation analysis to select the corresponding optimization index, solve multi-objective programming problem to find the best partner of cloud services by the way of using genetic algorithm, and finally to verify the effectiveness and rationality of the algorithm and the model by the case.

2. THE PROBLEM AND THE MODEL

2.1 The Problem Description

The partner selection problem about the dynamic alliance of the cloud service providers: In order to select the cloud service provider partners, to form the dynamic alliance, and to build the corresponding index system of dynamic alliance. This article assumes that the overall goal of dynamic alliance is to achieve the optimal allocation of the cloud services market resources, and to improve the economic utility of resources. It select the optimized index by the comprehensive evaluation model of grey correlation analysis [7] [8]. The following is evaluated and analyzed:

It should set the reference sequence $x_0(k)$,which is the factor sequence about the optimized allocation rate for cloud service resources. The $x_i(k)$ is the compare sequence that is index factor under optimization. Among them $k=1,2,...,n$, $i=1,2,3,...,m$, The factor here is the

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change point of the target sequence. Based on the theory of the grey relational analysis, it has established the following formula: (1)

$$\xi(X_0(k),X_i(k))=\frac{\min\limits_{l}\min\limits_{k}|x_0(k)-x_i(k)|+\rho\cdot\max\limits_{i}\max\limits_{k}|x_0(k)-x_i(k)|}{|x_0(k)-x_i(k)|+\rho\cdot\max\limits_{i}\max\limits_{k}|x_0(k)-x_i(k)|}$$

$\xi(X_0(k),X_i(k))$ is the grey relational coefficient about the rate of the cloud service resources optimized allocation.

(2) $\xi(X_0(k),X_i(k))=\frac{1}{n}\sum_{k=1}^{n}r(X_0(k)-X_i(k))$

The $\xi(X_0(k),X_i(k))$ is the index factor of the Service for optimization and the correlation about the rate of the cloud service resources optimized allocation. It embodies the influence measure about the optimal allocation of resources of the index factor.

（3） $\delta(X_0,X_i)=\frac{\xi(X_0,X_i)}{\sum_{i=1}^{N}\xi(X_0,X_i)}$

The $\delta(X_0,X_i)$ is the relative weight measure of the optimization allocation rate for the cloud service resources owned by the index factor about the optimized service. It reflects the relative importance of the index attribute belong to the optimized allocation of resources.

Through the above theoretical analysis, It can determine the top three optimization index factor measured by the relative weights according to the above formula (3).That is (1) the cost factor provided by the required service, (2) the factor of the reaction time required by the service, (3) the attributes factors of the service quality. So the optimization goal of this article is the service costs (C) generated by the each cloud service providers in alliance, including the new software service for the establishment of the dynamic alliance (saas), the platform services (paas), the infrastructure services (Iaas) the need to cost. The required reaction time (T) generated when the cloud service's provider jointly offer the service to the terminal customer in the dynamic alliance. The service quality (Q) provided by cloud service's provider in the dynamic alliance.

So based on the demand of the above goal, the following factors should be considered as the cloud service providers: the cost of service, the service response time, and the quality of service. These factors can be expressed in objective function. So if chosen the cloud service provider partners, the purpose is to optimize the objective function, and makes the dynamic alliance group is more competitive, and it can bring more benefits to members of the alliance, so we think it is the multi-objective optimization problems to select the proper cloud service providers.

The partner selection problem about cloud service providers can be described as: Assuming that the core of dynamic alliance should provide service to the terminal users of n .To the special task, there are m cloud service providers to offer services to customers, so our optimization goal is to complete each task with selecting the best suitable partner, the problem can be described as the following:

The task $w=\{w_r\}=[w_1,w_2,w_3,...,w_n]$, *r=1,2，…，n*

For the task there is candidate partners as follows:

$p_r=\{p_{rj}\}=\{p_{r1},p_{r2},...,p_{rm}\}$, *j=1，2,…，m*

The candidate partners $p_{rj}=[c_{rj},t_{rj},q_{rj}]$ represent the cost, response time and quality.

2.2 Establish The Mathematical Model

Start with the basic model of multi-objective optimization [9] :

$G(x)=\min[g_1(x),g_2(x),...,g_n(x)]$

$s.t.\ f_r(x)\geq 0$

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Among them: $f_r(x)$---constraint condition;

$g_r(x)$---objective function For the partner selection problem of the cloud service providers, in order to guarantee the effectiveness of choosing the partners, the following objective function that the dynamic alliance is composed of to be met.

(1) Define the 0-1 variables:

$$\theta_{rj}=\begin{cases}1 & \text{if choose the } p_{rj}\\ 0 & \text{otherwise}\end{cases}$$

p_{rj}stand for the task r completed by the candidate partners j

Among $\sum_{r=1}^{n}\theta_{rj}=1 \quad j=1,2,3\ldots m$

(2) define the objective function

According to the problems described above, the selected service cost, response time and service quality as the three objective function:

Objective function 1: in the dynamic alliance, the minimum cost C of partner candidates for cloud service: *minC(*the price of CP（cloud provider r for service j) .

$$Minimize\ obj\text{-}1=\sum_{j=1}^{n}\sum_{r=1}^{m}C_{rj}\theta_{rj}$$

Objective function 2: in the dynamic alliance, the minimum response time T of partner candidates for cloud service: *MinT*:

$$Minimize\ obj\text{-}2=\sum_{j=1}^{n}\sum_{r=1}^{m}T_{rj}\theta_{rj}$$

Objective function 3: in the dynamic alliance, the best quality Q of partner candidates for cloud service: *maxQ:*

$$Maximize\ obj\text{-}3=\sum_{j=1}^{n}\sum_{r=1}^{m}q_{rj}\theta_{rj}$$

(3) The solution of the multi-objective optimization model:

For the multi-objective optimization problems, the multi-objective optimization function can be converted into the single objective optimization function, so the following objectives can be used for this form:

$$Minimize\ \ g(x)=w_1C+w_2T-w_3Q$$

w_k is stand for the weight. It determines the emphasis on the composition of each attribute in the dynamic alliance. $\sum_{k=1}^{3}w_k=1$

(4) The constraint conditions:

One partner is chosen at least by only one cloud service providers.

3. THE APPLICATION OF ANALYSIS

3.1 The Background Of The Case

It should be considered in the dynamic alliance that the cloud service provider will provide the following three services: the computing services (computing), the storage services (storage), the software, services to the terminal customer and the number of candidate partners is 3, 3, 5.The related data attributes of the candidate partners is seen in table 1: The cloud service provider that provide the above three kinds of services cloud services is named $A_{1,2,3}$, $B_{1,2,3}$, $C_{1,2,3,4,5}$. The task is to find the best cloud service provider candidate that completed the above task cooperation. The Specific data can be seen after the article in the appendix table1.

3.2.To Solve The Model

3.2.1 Determine the weighting factor

To determine the weighting factor W_i,

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i=1,2,3…n. To determine the weighting factor [11] should follow some certain principles: (1) the principle of usability, (2) the principle of maneuverability, (3) the principle of objectivity, (4) the principle of comparability, (5) the principle of comprehensive.

Set $X=\{X_1,X_2,\ldots X_m\}$ as the research object . It is the selected cloud service provider, $G=\{G_1,G_2,\ldots,G_n\}$, For the indicators of each object to measure. $W=\{W_1,W_2,\ldots,W_n\}^T$ for the index weight vector. $\sum_{j=1}^{n} W_j=1$.

$W_j\geq 0,(j=1,2,\ldots,n).$ $A=[a_{rj}]_{m\times n}$ a_{rj} stand for the object of study. That is to say the value that the cloud service providers X_r to the index G_j, because the counting dimension of each indicator is different, so we should standard the decision matrix, The decision-making matrix A is been standardized [12].

In order to determine the weight of each index, it create the following models:

$$\max Z=(Z_1,Z_2,\ldots,Z_m)$$

$$\text{s.t.}\ \sum_{j=1}^{n} W_j=1 \qquad W_j\geq 0,(j=1,2,\ldots,n).$$

among $z_r=\sum_{j=1}^{n}\frac{\left|a_j^*-a_{rj}\right|w_j}{1+\left|a_j^*-a_{rj}\right|w_j}$, a_j^* is the "Ideal value" of G_j.In practice, $a_j^*=\max\{a_{1j},a_{2j},\ldots a_{mj}\}$.The meaning of Z_r is the distance between the research object $X_r=\{a_{r1}w_1,a_{r2}w_2,\ldots,a_{rn}w_{rn}\}$ and the ideal solution $X^*_r=\{a^*_{r1}w_1,a^*_{r2}w_2,\ldots,a^*_{rn}w_{rn}\}$. Find a weight vector, makes the $Z_1,Z_2,\ldots,Z_n$ maximum. The aim is to distinguish the research object largely and to find the optimal solution clearly.

Adopt the method of linear solutions for the above model:

$$\max Z'=\sum_{r=1}^{n} z_r=\sum_{j=1}^{n}\frac{\left|a_j^*-a_{rj}\right|w_j}{1+\left|a_j^*-a_{rj}\right|w_j}$$

$$\text{s.t.}\ \sum_{j=1}^{n} W_j=1 \quad W_j\geq 0,(j=1,2,\ldots,n).$$

By the above model, we get the conclusion that $W=\{W_1,W_2,\ldots W_n\}$.

3.2.2. The quantitative process of qualitative indicators about the quality of service (Qos)

(1) The availability: The ability that the cloud services provided under the prescribed conditions and the constraint time can be accessed by the user successfully; you can use the following formula to express**:**

$$QoS_{avaliabity}=A/N$$

Among them A for the number of services provided that successful visited, N for the number of total visits by the customers.

(2)The reliability: The ability that the application services offered stable by the cloud service providers. It can be represented by the following formula: $QoS_{reliability}=R/M$, R for the number that the service implemented successful, M for the total number that the service called[13].

(3)The scalability: The ability that dynamic scaling with the needs cloud service, it can be expressed by the following formula:

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$QoS_{scalabilty} = \frac{\sum_{i=1}^{k} RS_i}{k}$, K for the total number of required service, RS_i for the success of the service call [14]. If successful, then $RS_i = 1$,then $RS_i = 0$.

(4) The integration: The ability that the cloud services can be provided by the system which can perform well with the applications systems belong to the enterprise customers, with an average score of the user said, $QoS_{\text{int egration}} = \frac{\sum_{i=1}^{n} AS_i}{n}$.Although the score that a single user ratings is subjectivity, but when the number of users is large, the average score is credible, AS_i represents a single user i ratings, n represents the general users [15].

3.2.3. The cost details

The specific cost details of the flow can be seen in the appendix table 2,after the paper.

3.2.4 The problem about computing the quality of service(Qos)

According to section 3.2.1, it can determine the weighting
factor on: The weight of the service quality of sub-layer:

$$\omega_1=0.31, \omega_2=0.27, \omega_3=0.22, \omega_4=0.20$$

$$Qos_{value} = \omega_1 QoS_{avaliabity} + \omega_2 QoS_{reliability} + \omega_3 QoS_{scalabilty}$$

The specific attribute value after the weighted Qos can be seen in the appendix table 3.

3.2.5. The processing of data standardized

Because the different indicators is different in dimension, it is indispensible to standard these indicators. with X = {X_1, X_2,... X_n} for the raw data, Y = {Y_1, Y_2,... Y_n} for the processing data, *minX* to the lowest value of a set data**,** *maxX* to the largest value of a set data.

The process of Standardization: $Y_i = \frac{X_i - \min X}{\max X - \min X}$

The normalized data can be seen in the table appendix 4.

4. THE GENETIC ALGORITHM IMPLEMENTATION OF MULTI-OBJECTIVE OPTIMIZATION MODEL

4.1.The Process Of Based Genetic Algorithm

The basic steps of genetic algorithm are as follows:

Step. The code. For the 0-1 integer programming, the variables will involve only adopt 0or1, it is directly coding with binary.

Step. The initial population generated. The starting point of the optimization is initial population generated. The size of the initial population determines the initial search space. We adopt the population size according the problem size $N = 10$. The initial population is randomly generated, to the cloud service providers (such as computing services), its formula is as follows:

$$x_1 = round(rand) \quad ,$$

$$x_j = round((1 - \sum_{i=1}^{j-1} x_i) * rand)$$

$round$ for integer, $rand$ for a random number generated between[0,1].

Suppose that a individual coding is as follows:

0	0	1	0	0	1	1	0	0	0	0

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It is said that we had chose the third provider of computing services, the third provider of storage service and the first provider of software provider.

Step. Calculate the fitness. After the data standardized to the section [0,1]. The scope of the objective function is $|g(x)| \le 3$, So the moderate function is taken by $fitness(x) = -g(x) + c$, $c \succ 3$.In practice**,** the value is $c = 5$.

Step.④The choice. The choice is to ensure that the best individual of the cloud service providers can insert into the next generation of new groups. Here we adopt the roulette method and the method of the optimal retention. The roulette method is calculated according to accumulate the fitness of individual, we can use the formula is expressed as:

$$fit_i = \frac{fitness_i}{\sum fitness_i}$$ The Molecules for the individual's fitness, the denominator for the sum of the fitness to the whole population. The random number is generated by the random population size. If $fit_{i-1} \le rand \le fit_i$, The individual of i is chosen to participate in the genetic operation. The optimum reserved strategy is to save the corresponding individual in the current optimal solution that is not to participate in the next genetic operation, after the other individuals to participate in the genetic operation, with the individual instead of the individuals with the lowest fitness at this time. It can ensure that the number of individuals in the process of population evolution is more and more.

Step.⑤The crossover and The mutation. For the problem of the cloud service provider selection, in order to satisfy the constraint conditions, and we adopted a strategy of overall cross between partitions. It will be generated randomly the three numbers within the scope of [1,11], then the task is to see which range [1, 3], [4, 6], [7,11]the three data fall into, to identify the part of the crossover operation to be done**.** The probability of crossover $P = 0.9$, The variation is a multipoint mutation, we also adopted the three random number generated between [1, 11]. According to the scope of data, we identity the code that need to change. The probability of mutation is set according to the ideas of the simulated annealing algorithm. In the early evolution, the probability of mutation is small. Along with the unceasing evolution, the probability of mutation is gradually increase.

Step.⑥Repetitive execution.

Step.③-

Step.⑤Until the termination conditions is satisfy, The termination condition is that the number of iterations is less than the maximum number of iterations. Here is the number of iterations $T = 50$.

4.2The Analysis About The Result

According to the model, we solve the problem with the Mat lab programming. The specific results as shown in the figure below:

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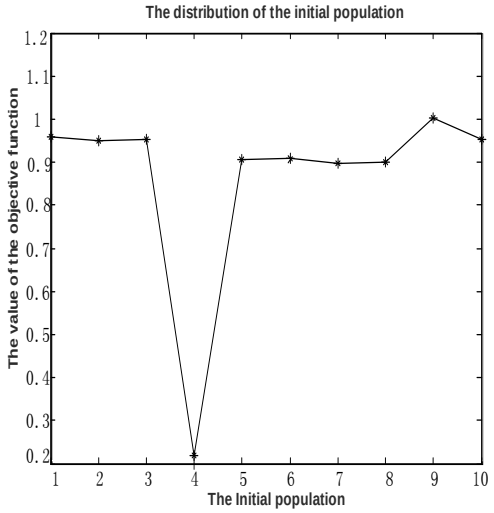

Figure 1: The Initial Population Distribution

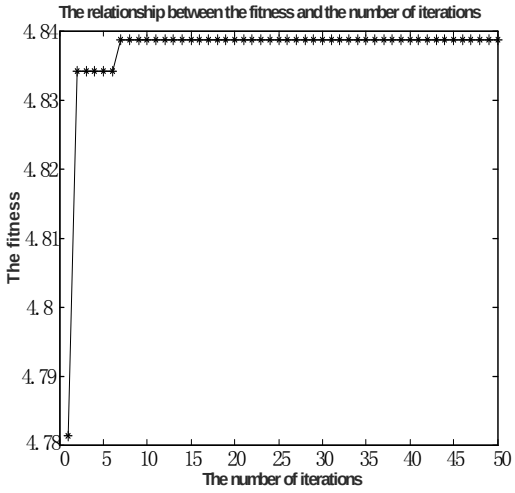

Figure 2: The Diagram Of Fitness And The Number Of Iterations

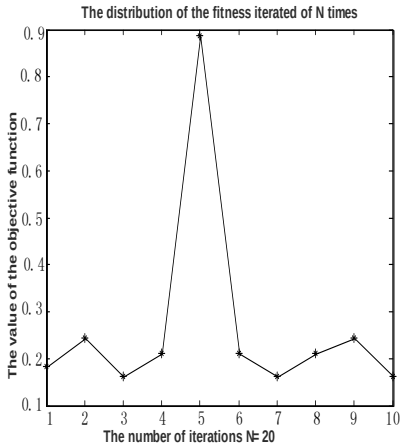

Figure 3: The Function Value Distribution Of Iteration

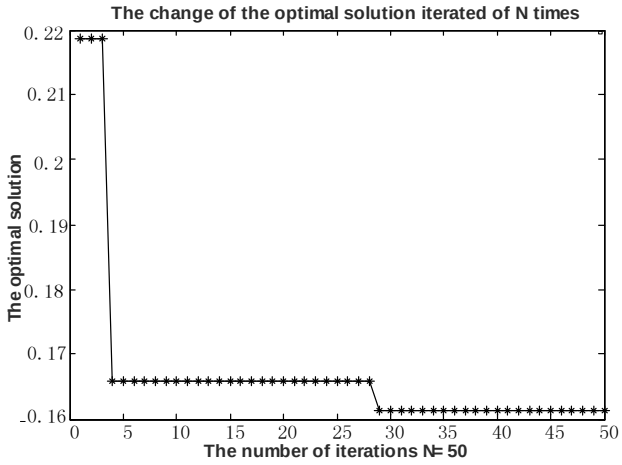

Figure 4:The Distribution Of the Fitness Iterated 20 Times

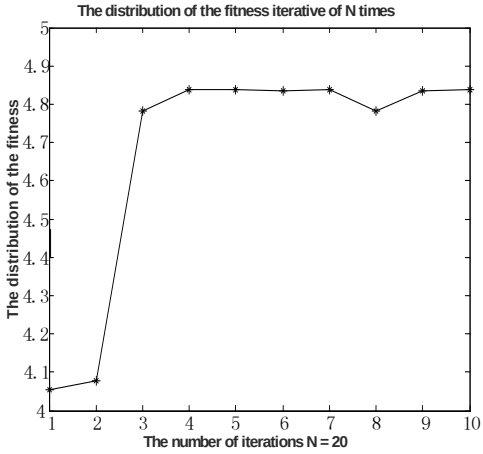

Figure 5: The Average Value Distribution And The Solution Changes Iterated After 50 Times

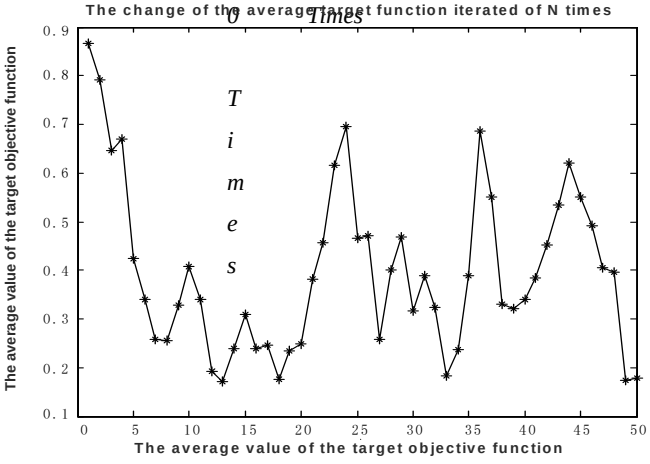

Figure 6: The Average Value Variation Of The Objective Function

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Optimal Iterated After 50 Times

According to the section 3.2.1,we determine the factor weights W_1=0.9，W_2=0.9，W_3=0.05. The best fitness value of the multi-objective optimization can be seen from the figure 2 is 4.8387, so as to get the partner selection results of the best optimization: The computing service A_1, The storage services providers B_1, The software services providers C_2, That is to say the best combination of dynamic alliance is (A_1, B_1, C_2).

We randomly select the objective function value belong to any group of 10 service group to compare with the best cloud service providers (A_1, B_1, C_2), The results are shown in figure 7 below:

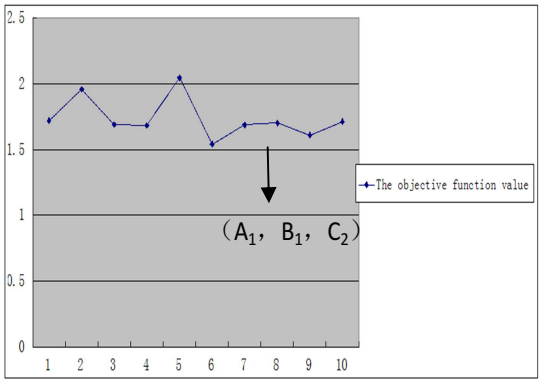

Figure 7: The Comparison Chart Of The Best Service Composition

It can be seen from the above, that the minimum value of the objective function is the best service group(A_1, B_1, C_2) ,corresponding to the rest randomly selected 10 service groups. Thus it can show that (A_1, B_1, C_2) is one of the best group in this paper.

5. CONCLUSION

The dynamic alliance partner selection of cloud service providers is an important and complex process. It is the key that we choose the suitable and competitive partner in the dynamic alliance, and optimize the cloud services resource, and it has very important theoretical and realistic significance. This paper proposes a method of cloud service providers to choose partners. We adopt the multi-objective optimization model, and consider the multiple factors affecting cloud service providers, use the genetic algorithm, to find the best fitness value, finally it find out the best cloud services combination plan. Through the experimental results show that the validity and practicability of the method. In this paper, it put forward the exploratory model for choosing the best partner of the cloud service providers in dynamic alliance. The model provide empirical research foundation for this study.

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APPENDIX:

The function of Provide the service	The Candidates for the cloud service provider partners	Annual cost (RMB)	Response time (s)	The quality of Service (Qos)			
				Availability (%)	Reliability (%)	Integration (%)	scalability （%）
The Computing services	*A1*	7415.04	9	92	93	89	90
	A2	8000	5	95	93	96	97
	A3	8002.26	7	94	94	90	92
The Storage service	*B1*	6136.32	3	98	99	97	96
	B2	8149.12	4	97	98	95	94
	B3	8688.46	6	96	95	92	96
The Software services	*C1*	7800	8	95	96	94	93
	C2	5280	14	93	92	88	90
	C3	6400	10	96	97	98	95
	C4	7200	12	94	95	92	91
	C5	5460	11	95	94	93	94

Table 1: The Related Data Of The Candidate Partners [10]

(The source: the above data are for amazon,google,salesforce,Microsoft,oracle,xtools, The cloud of the West lake, sina.)

Table 2: The Table Of Calculating The Flow Cost

The flow	The cost
First a GB/month	C_1 Per GB
Next b GB/month	C_2 Per GB
Next c GB/month	C_3 Per GB
Next d GB/month	C_4 Per GB

$$C(X)=\begin{cases} X*C_1*12 & a\leqslant X<b \\ X*C_2*12 & b\leqslant X<c \\ X*C_3*12 & c\leqslant X<d \\ X*C_4*12 & X\geqslant d \end{cases}$$

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Table 3: The Attribute Value Table After The Weighted Qos

The function of Provide service	The Candidates for the cloud service provider partners	The attribute values of Service quality
The Calculator Service	*A1*	91.2100
	A2	95.0800
	A3	92.7200
	B1	97.6500
The Storage service	*B2*	96.2300
	B3	94.8500
	C1	94.6500
The Software services	*C2*	91.0300
	C3	96.5100
	C4	93.2300
	C5	94.0900

Table 4: The Tables Of Data Normalized

The function of Provide service	The Candidates for the cloud service provider partners	The Annual cost (RMB)	The Response time (s)	The quality of Service
The Calculator Service	A1	0.0309	0.5455	0.0272
	A2	0.1391	0.1818	0.6118
	A3	0.0595	0.3636	0.2553
The Storage service	B1	1.0000	0	1.0000
	B2	0.9364	0.0909	0.7855
	B3	0.1446	0.2727	0.5770
	C1	0.0020	0.4545	0.5468
The Software services	C2	0	1.0000	0
	C3	0.0025	0.6364	0.8278
	C4	0.0015	0.8182	0.3323
	C5	0.0015	0.7273	0.4622