Research on Cloud Test Resource Allocation Based on Improved Fuzzy Clustering PSO Algorithm

Weijie Kang¹*, Jiyang Xiao² and Xiaoruo Kong³

¹Aeronautics Engineering College, Air Force Engineering University, Xi’an, China
²ATC and Navigation College, Air Force Engineering University, Xi’an, China
³Journalism School, Fudan University, Shanghai, China

*Corresponding author e-mail: milankang@foxmail.com

Abstract. There are few related researches on cloud hardware test resource allocation, and the existing common methods have low reliability and slow solution speed. The matching calculation based on fuzzy clustering and the resource allocation method based on improved PSO are proposed. Firstly, seven typical parameters of cloud test resources are proposed, and the dynamic resource matching effectiveness evaluation model is established. Secondly, the Delphi method is used to evaluate the parameters fuzzily. The resource matching degree is calculated based on fuzzy rules and cosine similarity. Then the cloud test resource necessity and priority matching are proposed. Strategy, using the improved PSO algorithm to achieve approximate optimal resource allocation; Finally, the algorithm is used to verify and analyze the algorithm, and applied to a cloud test platform. The results show that the method not only solves faster, but also improves the quality of resource matching.

1. Introduction

Test resource matching is the process by which the cloud test platform allocates the required virtual test resources according to the signal type and test requirements in the test task. It is the premise for realizing the test task scheduling and the basis for the efficient operation of the cloud test system[1].

The test resource matching problem (MR) is essentially an NP-hard problem[2], and the multi-task parallel and multi-resource sharing features of the parallel cloud test increase the problem scale geometrically, and the system is difficult to match the test task set to the shortest time in a short time. Excellent resources, which in turn affects the efficiency of the test system. In addition, the existing cloud test system has problems such as poor adaptability of resource matching metrics[3], low reliability of common methods, slow calculation speed of algorithms, poor performance of resource matching, resulting in unbalanced resource load and long task scheduling. Therefore, how to establish an efficient and reliable resource matching method has been widely concerned at home and abroad.

2. Cloud test resource matching and typical parameters

The requirements of the test task are very complicated[4]. To facilitate the discussion of the problem, the model is simplified as: a matching model of t test tasks and r test resources in equation (1) [5,6].

\[ \beta = \begin{bmatrix} tr_{t,1} & \cdots & tr_{t,r} \\ \vdots & \ddots & \vdots \\ tr_{t,1} & \cdots & tr_{t,r} \end{bmatrix} \]  

(1)
∀ \in t, \sum_{j=1}^{r} t_{r, j} = 1  \quad (2)
∀ \in r, \sum_{i=1}^{t} t_{r, i} = 1  \quad (3)

In the formula (1), the test resource is matched to the corresponding test task, indicating that the test resource is not matched to the corresponding test task. A test task of formula (2) can only occupy one test resource, and formula (3) means that the same test resource can only correspond to one test task at the same time.

Through the establishment of resource dynamic matching effectiveness evaluation model, fuzzy evaluation of dynamic parameters such as health status, fuzzy decision avoidance rules for accidental factors, and intelligent allocation of cloud test resources.

3. Improved PSO algorithm for cloud test resource matching

3.1. Dynamic matching efficiency evaluation model

Definition 1: The Cloud Test Resource Matching (CTRM), which indicates how well the test resource matches the test task. Defined as the cloud test resource matching degree of the test resource to the test task[7]. The value is between 0 and 1 is an optional match; the value is 1 is a positive match; 0 is a mismatch.

The cloud test resource matching is to match the preferred test resources for multiple test tasks, so that the overall matching performance is approximately optimal. Based on the resource allocation model, resource matching degree and dynamic health state proposed above, the resource matching performance function can be obtained as shown in equation (4).

\[
F(X) = \max \sum_{i=1}^{t} \sum_{j=1}^{r} t_{r, j} p_{i, j} \beta_j
\]  \quad (4)

3.2. Parameter fuzzy evaluation

In actual test tasks, the magnitude difference of each performance parameter is large, and the magnitude span of the same parameter may be large[8]. The traditional calculation method of matching degree, such as ratio or distance formula, is often unable to explain its meaning intuitively, and the distribution of result field is not uniform, so it is difficult to make unified comparison. Fuzzy evaluation using fuzzy statistics and expert knowledge can effectively solve the above problems. Therefore, fuzzy evaluation based on Delphi method is suitable for computing cloud test resource matching degree.

![Resource matching flowchart](image)

In the first stage, based on the Delphi method, the qualitative classification of each parameter was firstly conducted and then the classification interval was defined quantitatively[9]. Finally, the actual resource capacity or task demand value was substituted into the calculation, and the unified measurement standard of each parameter was obtained. In the second stage, the cosine similarity method was used to substitute the fuzzy evaluation vectors of test resource capacity and test demand, and the integrated resource matching value was obtained.
3.3. Resource allocation method
PSO is a simple and efficient heuristic search algorithm[10]. The algorithm has the advantages of simple principle, less controlled parameters and fast convergence speed, but it can only be used for continuous objective function. In order to solve the distribution model and solve the above problems, an improved PSO is proposed in this paper.

The main advantages of the improved PSO algorithm are: (1) the priority matching strategy is used to guide the search direction in the early stage, avoiding a large number of exploratory searches; (2) by using the method of overlapping the priority matching strategy with the population variation crossover step by step, the priority matching strategy can avoid the premature introduction of the algorithm into the "local optimum"; (3) the mutation operation is implemented by introducing difference operators to effectively improve the quality of solution.

4. Result analysis
Based on a test task instance of a private cloud testing platform[11], the matching degree matrix obtained by the fuzzy evaluation method is shown in Table 1.

| Resource | R1    | R2    | R3    | R4    | R5    | R6    |
|----------|-------|-------|-------|-------|-------|-------|
| T1       | 0.8713| 0.9247| 0.6783| 0.1849| 0.0   | 0.8997|
| T2       | 0     | 0.3234| 0     | 0.5021| 0.4173| 0.1494|
| T3       | 0     | 0     | 0     | 0     | 0     | 0.6229|
| T4       | 0     | 0.2758| 0     | 0.1055| 0     | 0.3716|
| T5       | 0     | 0     | 0     | 0     | 0     | 0.6229|
| T6       | 0.1513| 0.3499| 0.3885| 0.8524| 0.3882| 0.1964|

Based on the above data, using the improved PSO algorithm, the resource matching results are shown in Table 2.

| Resource | R1    | R2    | R3    | R4    | R5    | R6    |
|----------|-------|-------|-------|-------|-------|-------|
| T1       | 1     | 0     | 0     | 0     | 0     | 0     |
| T2       | 0     | 0     | 0     | 0     | 1     | 0     |
| T3       | 0     | 0     | 0     | 0     | 0     | 1     |
| T4       | 0     | 0     | 0     | 0     | 0     | 0     |
| T5       | 0     | 0     | 0     | 1     | 0     | 0     |
| T6       | 0     | 0     | 1     | 0     | 0     | 0     |

In order to analyze the convergence speed, solution speed and solution quality of the improved PSO algorithm, compare it with DDE algorithm and PSO algorithm, run 20 times under the same simulation conditions, get the mean value of the ratio of performance function value to theoretical value, and the number of iterations. The relationship is shown in Figure 2.

![Figure 2. Algorithm fitness.](image)

It can be seen from the above results that: (1) The improved PSO algorithm has a faster convergence rate in the early stage and can approach the theoretical solution faster; (2) after several
iterations, the average quality of the solution is slightly higher than the DDE and RR algorithms; (3) The calculation speed is obviously superior to the other two algorithms.

5. Conclusion
A matching method based on fuzzy inference and an algorithm based on improved PSO are proposed. Firstly, the fuzzy evaluation of dynamic parameters such as health status and the avoidance rule for accidental factors are solved, which solves the poor adaptability and low reliability of traditional matching algorithms. The problem is to achieve reliable matching of cloud test resources. Secondly, the improved PSO algorithm is proposed to solve the problems of traditional heuristic algorithm in the early stage of a large number of exploratory search and easy to fall into local optimum, and realize the rapid solution of the distribution model. Finally, through simulation experiments and Engineering practice analyzes and verifies the effectiveness of the relevant algorithms. The algorithm proposed in this paper has been applied to a private cloud test platform, which effectively improves the resource matching performance of the cloud test system.

References
[1] XIAO M Q,Yang Z,Zhao X. The Concept of Cloud Testing and Its Application Exploration[J]. Computer Measurement & Control,2016,(1): 1-3+11.
[2] Tindell K. W., Burns A., Wellings A. J. Allocating hard real-time tasks: an NP-hard problem made easy[J]. Real-Time Systems, 1992, 4(2): 145~165.
[3] GAO X,LIANG Z W,XU G Z. Service resource selection mechanism based on function matching[J]. Chinese Journal of Scientific Instrument, 2012, 33(12): 2647-2654.
[4] LI C H,HUANG B Q. A Cloud Manufacturing Service Resource Search Method Based on Attribute Description Matching[J]. Computer Integrated Manufacturing Systems, 2014, 20(06): 1499-1507.
[5] FU X H,XIAO M Q. A Method for Automatic Configuration of ATS Resources Based on a Matching Function[J]. Journal of Beijing University of Aeronautics and Astronautics, 2008, 34(12): 1392-1397.
[6] CHEN H H, ZHAO L, YAN H, LUO X S. Study on Matching Model and Solution Algorithm between Combat Tasks and Resources[J]. Systems Engineering and Electronics, 2008, (9): 1712-1716.
[7] GU Y L. Scheduling implementation of parallel tasks in cloud testing [D]. Donghua University, 2014.
[8] TIAN J,ZHANG P Z, WANG Z L, WANG Y L. Research on Expert Opinion Integration Model Based on Delphi Method[J]. Systems Engineering — Theory & Practice, 2004(01): 57-62+69
[9] Miettinen K., Mäkelä M. M. On scalarizing functions in multiobjective optimization[J]. OR spectrum, 2002, 24(2): 193~213.
[10] XIE F W,ZHANG M. Cloud computing resource allocation scheme based on improved discrete particle swarm optimization[J]. Natural Science Journal of Xiangtan University, 2017, 39(03): 89-93.
[11] IEEE Standards Coordinating Committee 20. IEEE Std 1641™-2010. IEEE Standard for Signal and Test Definition[S]. New York: IEEE, 2010