Evaluation Research and Application of Cloud Service Provider Based on Real-Time Data

Tiao-juan HAN, Jian-feng LU* and Li TAO
Tongji University, No. 4800 Caoan Highway, Shanghai
*Corresponding author

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Abstract. How to choose the right supplier from many cloud service providers has become a research hotspot. Basing on real-time data, we propose a method for evaluating and choosing the supplier of Machine Tool. Firstly, we establish the index evaluation system of Machine Tool’s performance. Secondly, we apply analytic hierarchy process (AHP) and entropy method to determine the weights of performance indexes. We obtain the performance assessment by the weights. Thirdly, taking the cost into consideration, we calculate the comprehensive assessment score. Finally, we take two service suppliers as example, and draw a conclusion that the service capability of supplier 2 is better than that of supplier 1. The assessment method proposed in this paper provides a reference for matching the service provider and the service demander.

Introduction

Cloud manufacturing is an Internet-based manufacturing, sharing manufacturing resource and meeting the customization need. There are three main roles in the cloud manufacturing: service suppliers, cloud platform, and service demanders. The service supplier logs in the platform and releases information about the manufacturing resources such as production type and capacity. Then a resource pool is formed and various manufacturing resources are transformed into cloud service. The service demander logs in the cloud platform to release the information of the manufacturing task, including the quality requirement, the deadline, et al. After receiving the task, the cloud platform searches for the service in the resource pool and matches the appropriate service. As we can see, it is of great significance to select the appropriate service supplier in the matching process, so evaluating the service capability of the supplier is crucial. Based on real-time data, this paper proposes an evaluation method for the service provider.

Literature Review

In cloud service transactions, there are two types of participants: the service supplier and demander. From the supplier's point of view, there are three methods for evaluating the supplier: principal component analysis, analytic hierarchy process (AHP), and analytic network process. Bing Zhou et al. constructed an index system of evaluating cloud service and proposed an evaluation method based on principal component analysis [1]. Jiang-ning Cheng proposed the entropy AHP method to evaluate the service capability of the supplier [2]. Zant B et al. proposed a set of performance tests based on real measurement to evaluate the performance of cloud service providers [3]. Kumar R et al. discussed the fuzzy based analytic hierarchy process (fuzzy-AHP) in selection of cloud service provider with possible important criteria: cost, performance and security [4].

The above evaluation methods of cloud service did not consider service demanders. There are many studies on evaluating the supplier from the perspective of the service demander. Yan Wang presented a selection model to meet the demanders’ preference [5]. Li-rong Xiong proposed an evaluation model of users’ subjective feedback [6]. Wei-wei CHEN et al. considered the users’ feedback and constructed an evaluation system of non-functional service quality for cloud service [7].
There are also many studies about real-time evaluation. Yun-long Zheng proposed a real-time assessment model for scraper conveyors based on back propagation (BP) neural network [8]. Cardenas A et al. presented the adaptive linear neuron algorithm for real-time evaluation of power quality [9]. In addition, Jian-zhong Sun et al. presented Bayesian estimation theory to estimate the state of host system based on collected data [10]. Ren-shan Liu et al. proposed a real-time evaluation method for the security situation of host system based on hidden Markov model (HMM) [11].

Based on the above literature review, this paper proposed a real-time evaluation method for the service provider of Machine Tool according to collected data.

**Evaluation Method Based On Real-time Data**

**System Framework.** The cloud platform is the control center, which makes evaluation for the service provider. In this paper, evaluating the service provider can be realized by evaluating Machine Tool of the service provider. Firstly, the cloud platform receives performance test data from Machine Tool and calculates each performance index’s score. Secondly, the AHP and entropy method is used to determine the index weights of the Machine Tool’s performance [2], thus the performance of Machine Tool is evaluated. Thirdly, consider the cost to obtain a comprehensive assessment and calculate comprehensive score. Finally, according to the comprehensive score of each Machine Tool that belongs to the service provider, the service capability of the service provider is obtained so that the cloud platform matches the service task and the service supplier. Referring to the measurability of performance indexes, this paper selects four indexes of Machine Tool shown in Figure 1 to evaluate the Machine Tool, including positioning accuracy, spindle speed, feed rate, motor current. The four indexes can be measured in real time.

![Figure 1. The system framework.](image)

**Calculate Each Performance Index’s Score.** Take the calculation of the positioning accuracy as example. Firstly, determine the ratio of positioning accuracy value to standard value. Standard value refers to the mean value of Machine Tool’s positioning accuracy on the cloud platform. Then the ratio can be converted into the score of positioning accuracy by (1). Similarly, scores of other indexes can be also calculated.
Determine Performance Indexes’ Weights. When all scores of performance indexes are calculated, it is necessary to determine these indexes’ weights to get the result of performance test. Different weights lead to different evaluation score, so it is important to determine the weights appropriately to get the final evaluation result. There are many methods to determine the weights coefficient. This paper presents the AHP and entropy method to determine the weights for each performance index of Machine Tool as described below.

1) Determine the performance indexes’ weights by AHP

① Establish judgment matrix

It is of great significance to establish the judgment matrix. The importance scale from the element i to the element j is expressed by \( a_{ij} \). The higher the value, the more important the element i is than the element j. Obviously, the importance scale from the element j to the element i can be expressed by \( a_{ji} = 1/a_{ij} \). In this way, a judgment matrix \( I = (a_{ij})_{nxn} \) can be constructed.

The value of each element in the judgment matrix is determined by the relative importance of each performance index,

\[
I = \begin{bmatrix}
1 & 1 & 3 & 3 \\
1 & 1 & 3 & 3 \\
1/3 & 1/3 & 1 & 3 \\
1/3 & 1/3 & 1/3 & 1
\end{bmatrix}.
\] (2)

② Solve the indexes’ weights

The eigenvector that is “aligned” with the maximum eigenvalue is solved and normalized by eigenvalue and eigenvector formula \( \alpha = \lambda \alpha \). In EXCEL, calculate the weights and we can get the results shown in formula (3) and the intermediate process of calculation is shown in Table 1.

\[
\alpha^T = (0.371, 0.371, 0.163, 0.094).
\] (3)

| Judgment matrix | Multiplication | Quarter | Weight |
|-----------------|---------------|---------|--------|
| U1              | U2            | U3      | U4     |
| U1              | 1             | 1       | 3      | 3      | 9      | 1.732 | 0.371 |
| U2              | 1             | 1       | 3      | 3      | 9      | 1.732 | 0.371 |
| U3              | 0.33          | 0.33    | 1      | 3      | 0.333  | 0.760 | 0.163 |
| U4              | 0.33          | 0.33    | 0.33   | 3      | 0.037  | 0.439 | 0.094 |

2) Determine the performance indexes’ weights by entropy method

① Data standardization

The data of each performance index is collected. It is assumed that raw data is expressed by the matrix \( R = (r_{ij})_{nxn} \), where \( R = \{R_1, R_2, \ldots, R_n\} \) and \( R = \{r_1, r_2, \ldots, r_n\} \). The raw data is standardized by (4).

\[
d = (r_{ij} - \min(R_i)) / (\max(R_i) - \min(R_i))
\] (4)

② Calculate the proportion of each value by (5).
\[ p_i = d_i / \sum_{j=1}^{m} d_j \]  

(5)

Solve the information entropy of each index by (6).

\[ e_j = k \sum_{j=1}^{m} p_j \ln(p_j) \]  

\[ k = -\ln(m)^{-1} \]  

if \( p_i = 0 \), \[ \lim_{p_i \to 0} p_i \ln(p_i) = 0 \]  

(6)

4) Calculate the entropy weight of each index by (7).

\[ w_j = (1-e_j) \sum_{j=1}^{n} (1-e_j) \]  

(7)

3) AHP and entropy method

It is subjective to calculate the weight by AHP. On the contrary, it is objective to determine the weight by entropy method. Therefore, the entropy AHP method not only avoids subjective randomness, but also reduces the weight deviation from the actual situation [2]. First, the weight of the index \( j \) is determined by AHP as \( \alpha_j, (j=1,2\ldots n) \), and the weight of the index \( j \) is determined by the entropy method as \( w_j, (j=1,2\ldots n) \), and finally calculate the weight by (8).

\[ \beta_j = \alpha_j w_j / \left( \sum_{j=1}^{n} \alpha_j w_j \right) \]  

(8)

Knowing the scores and weight of each performance indicator, the entire score of performance test can be obtained.

Calculate comprehensive score. In order to get the comprehensive score, it is of great necessity to determine the weights between the performance and cost. The weights can be adjusted. For example, if the performance is more important than the cost, it is necessary to increase the weight of the performance. Then calculate the entire score of Machine Tool according to the weights between the performance and cost. The comprehensive score of the supplier’s each Machine Tool is different. The average of comprehensive scores can’t represent the real ability of the service supplier. Therefore, comprehensive score of the supplier’s Machine Tool is divided into five evaluation levels \( V = \{V_1, V_2, V_3, V_4, V_5\} \), \( V_1 = \{ \text{very good} \}, \ V_2 = \{ \text{good} \}, \ V_3 = \{ \text{general} \}, \ V_4 = \{ \text{poor} \}, \ V_5 = \{ \text{very poor} \} \), which are “aligned” with \( [0.8,1] \), \( [0.6,0.8) \), \( [0.4,0.6) \), \( [0.2,0.4) \), \( [0,0.2) \) respectively. Finally count the number of Machine Tool in different interval. The cloud platform selects the supplier according to actual service requirement.

Case

Taking ten Machine Tools from two suppliers as example, the performance evaluation is carried out. By (4)-(7), the entropy weights of the four performance indicators of two suppliers are calculated and shown in formula (9),

\[ \begin{cases} w_1^T = (0.252, 0.245, 0.235, 0.267) \\ w_2^T = (0.251, 0.253, 0.245, 0.251) \end{cases} \]  

(9)

Then calculate the comprehensive weights of the two suppliers’ Machine Tool by (3) and (9),
\[
\begin{align*}
\beta_1^T &= (0.377, 0.367, 0.155, 0.101) \\
\beta_2^T &= (0.372, 0.374, 0.159, 0.094). 
\end{align*}
\] (10)

Performance scores are calculated based on the comprehensive weights by entropy AHP method. The weights of the performance and cost are set to 0.7 and 0.3 to calculate the comprehensive score of each Machine Tool. Ps refers to scores of performance test, C refers to the cost, and S refers to comprehensive score. The calculation results are shown in Table 2 and 3.

Table 2. Evaluation result of supplier 1.

| Num | Index1 | Index2 | Index3 | Index4 | Ps   | C   | S   |
|-----|--------|--------|--------|--------|------|-----|-----|
| 1   | 0.687  | 0.869  | 0.324  | 0.989  | 0.72 | 6   | 7   |
| 2   | 0.157  | 0.131  | 0.064  | 0.449  | 0.16 | 3   | 3   |
| 3   | 0.079  | 0.227  | 0.12   | 0.003  | 0.13 | 2   | 2   |
| 4   | 0.868  | 0.478  | 0.208  | 0.926  | 0.62 | 9   | 6   |
| 5   | 0.071  | 0.059  | 0.74   | 0.105  | 0.17 | 3   | 4   |
| 6   | 0.336  | 0.51   | 0.151  | 0.436  | 0.38 | 1   | 3   |
| 7   | 0.928  | 0.06   | 0.41   | 0.684  | 0.50 | 5   | 4   |
| 8   | 0.854  | 0.882  | 0.901  | 0.561  | 0.84 | 2   | 5   |
| 9   | 0.724  | 0.653  | 0.147  | 0.897  | 0.62 | 6   | 4   |
| 10  | 0.848  | 0.89   | 0.212  | 0.403  | 0.72 | 0   | 5   |

Table 3. Evaluation result of supplier 2.

| Num | Index1 | Index2 | Index3 | Index4 | Ps   | C   | S   |
|-----|--------|--------|--------|--------|------|-----|-----|
| 1   | 0.868  | 0.051  | 0.244  | 0.93   | 0.46 | 9   | 5   |
| 2   | 0.779  | 0.378  | 0.284  | 0.517  | 0.52 | 5   | 4   |
| 3   | 0.594  | 0.139  | 0.661  | 0.064  | 0.38 | 5   | 3   |
| 4   | 0.634  | 0.582  | 0.221  | 0.019  | 0.49 | 1   | 2   |
| 5   | 0.702  | 0.635  | 0.043  | 0.698  | 0.57 | 2   | 8   |
| 6   | 0.2    | 0.252  | 0.66   | 0.458  | 0.31 | 7   | 4   |
| 7   | 0.748  | 0.396  | 0.21   | 0.546  | 0.51 | 2   | 1   |
| 8   | 0.341  | 0.6    | 0.31   | 0.4    | 0.43 | 8   | 6   |
| 9   | 0.882  | 0.476  | 0.579  | 0.916  | 0.68 | 5   | 6   |
| 10  | 0.141  | 0.791  | 0.993  | 0.665  | 0.56 | 9   | 6   |

After the comprehensive scores of two suppliers’ Machine Tool are calculated, Figure 2 is a statistical graph of two suppliers’ Machine Tool in different scoring intervals.
As shown in Figure 2, comprehensive scores of Machine Tool are mostly between 0.4 and 0.8. By comparison, the supplier 2 has more Machine Tool between 0.4 and 1. Thus, it is found that the service capability of supplier 2 is better than that of supplier 1 on the whole. When the cloud platform matches the task and the service provider, the supplier 2 is referentially selected. For the production process with high precision, supplier 1 can be prior to supplier 2 since supplier 1 has ten percent of Machine Tool between 0.8 and 1.

Summary

This paper selects the performance and cost of Machine Tool as evaluation indexes to evaluate the service capability of suppliers. We present the entropy AHP method to determine the indexes’ weights of Machine Tool’s performance, avoiding the subjectivity by AHP. It is a further study about the evaluation indexes for different equipment.

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