Analysis of Influencing Factors for Cloud Service Composition Flexibility Based on Fuzzy Evaluation Method

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Abstract. There are various uncertainties in the process of cloud service composition, which increase the probability of failure of cloud manufacturing platform, resulting in manufacturing task cannot be completed timely and effectively. Improving the flexibility of cloud service composition can effectively reduce the failure of cloud manufacturing platform. Therefore, it is necessary to study the cloud service composition flexibility. In this paper, the flexibility of cloud service composition and its influencing factors were analyzed. Because the cloud service composition has too many uncertainties, so the fuzzy evaluation method model was built to analyze the influencing factors of cloud service composition flexibility, and then the key factors were identified. This paper offers the groundwork for the subsequent influencing factors monitoring and cloud service composition flexibility measuring.

1. Introduction
Cloud manufacturing (CM) combined with cloud computing, networking, service-oriented, virtualization and some new technologies, it supports manufacturing resources and manufacturing abilities to implement the distributed manufacturing resource sharing and cooperation based on Internet according to the need. It can also effectively integrate manufacturing resources and abilities in the whole life cycle of manufacturing process, and improve its efficiency and cut down the consumption of resources, and to realize green manufacturing and service oriented manufacturing with providing a new train of thought[1].

In cloud manufacturing, single service resources cannot meet the increasingly complex manufacturing tasks, so we need cloud service composition (CSC) to meet the demand. But there is no one optimal solution; we can just use the existing technologies and methods to get a satisfactory solution or non-inferior solutions. Thus, there are various uncertainties in the process of cloud service composition, which increase the probability of failure of cloud manufacturing platform (CMP), resulting in manufacturing task cannot be completed timely and effectively. Improving the flexibility of cloud service composition can effectively reduce the failure of cloud manufacturing platform. Therefore, it is necessary to study the cloud service composition flexibility (CSCF). In response to these uncertainties existing in the process of cloud service composition, a fuzzy evaluation method model was built to analyze the importance of the influencing factors of cloud service composition flexibility, and then the key factors were identified. It put the groundwork for the subsequently estimating and monitoring work by this paper.

2. Influencing Factors of Cloud Service Composition Flexibility
Many scholars have given the definition and analysis of flexibility and interpretation of its meaning,
although they cannot get a uniform definition of flexibility, a variety of flexibility definitions have in common that it is an ability to deal with changes in the uncertainty system. "Ability" and "Uncertainty" are key elements in flexibility definition. At present, the flexible studies are found in manufacturing system and supply chain system [2]. Few scholars have studied manufacturing cloud services composition flexibility. Tao pointed out that the cloud service composition flexibility is defined as the ability that in the life-cycle of cloud service composition, when cloud service composition receives the external force or internal force, the resulting expected or unexpected dynamic changes can be responded and the flow of cloud service composition can be autonomously dynamic reconfigured to complete the tasks [3]. On the basis of previous studies, this paper argues that cloud service composition flexibility is that when the uncertainty events occur, the ability that cloud service composition can complete the tasks successfully.

As mentioned above, There are many uncertainties when manufacturing cloud service resources combine dynamically, such as resource services (RS) join or exit, tasks change (TC) and composition status and quality of service (QoS) change, as well as resource service associations (RSA) change, these uncertainty factors lead to cloud service composition cannot complete manufacturing tasks effectively and high-quality. As shown in Figure 1.

![Figure 1 Uncertainty in CSCF](image)

Aiming at the uncertainty factors, TaoFei [3] proposed several influencing factors of cloud service combination flexible, for the purpose of these article ideas have revelatory effect; in order to facilitate the establishment of the fuzzy evaluation model, these factors can be divided into two levels in this paper.

2.1. Resource Service

Resource service refers to the cloud manufacturing system malfunction caused by the cloud service resources problem in cloud service combination process, and the service resources can be reflected by its second hierarchy in all kinds of influence factors, including resource services overload, dynamic join and exit.

2.2. Resource Service Associations

Resource service associations refer to the problems between the service resources in the past leading to the cloud service combination to reset, showed by all kinds of factors in the second hierarchy, including changes in syntagmatic relations, business entity relationship changes and statistical cooperation changes.
2.3. Tasks Change
Tasks change refers to the tasks change without expectation leading to the cloud manufacturing system malfunction, embodied by the various factors in the second level, including task suspension, requirements change, cancellation and reset.

2.4. Quality of Service
Quality of service refers to the cloud manufacturing system malfunction caused by resources service quality problems, the service quality includes several aspects; this article selects several representative factors as the second level, including time, price, availability, reliability and credibility. As shown in Figure 2.

![Figure 2 Influencing Factors of CSCF](image)

3. Establishment of the Fuzzy Evaluation Model
Fuzzy comprehensive evaluation method is a kind of bid evaluation method based on fuzzy mathematics. It translates the qualitative evaluation into quantitative evaluation according to the theory of fuzzy membership degree, namely using the fuzzy mathematics to make an overall evaluation for the things or object restricted by various factors [4]. It effectively combines the qualitative and quantitative evaluation, and the result is clearly and systemic strong, can well solve the fuzzy and hard to quantify problems, suitable for all kinds of uncertain problems.

The most prominent features of fuzzy comprehensive evaluation are mutual comparison and function relation. Mutual comparison refers to the best evaluation factor value as the benchmark, the evaluation value is 1; the rest of the less favorable evaluation factors are based on the degree of the inferior to get the corresponding evaluation value. Function relation means that the relationship between evaluation value and evaluation factor value can be determined according to the characteristics of various evaluation factors. There are many ways to determine this function relationship (membership function), such as F statistical methods, various types of F distributions, and so on. Of course, you can also ask an experienced bid evaluation expert to give a direct evaluation of the value.

Establishment of the fuzzy evaluation model:
(1) Determine the fuzzy evaluation factor set U.
   \[ U = \{ u_1, u_2, u_3 \cdots u_n \} \]
(2) Determine the fuzzy evaluation Comments set V.
\[ V = (v_1, v_2, v_3 \ldots v_m) \]

(3) For the single factor evaluation, establish the fuzzy relation matrix \( R \).
\[ R = (r_{ij})_{n \times m} \]
\[ r_{ij} \in [0, 1] \quad i = 1, 2, 3 \ldots n; \quad j = 1, 2, 3 \ldots m \]

(4) Determine the weights matrix of evaluation factors \( W, W = (w_1, w_2, w_3 \ldots w_n) \), distribute the weights according to the importance of various factors when judging them.
\[ 0 \leq w \leq 1, \quad (i = 1, 2, 3 \ldots n) \quad \text{and} \sum w_i = 1 \]

(5) Determine the evaluation rank row vector \( P, P_i \) is given according to different grade.
\[ P = (p_1, p_2, p_3 \ldots p_m), \]
\[ 0 \leq p_i \leq 100, \quad (i = 1, 2, 3 \ldots n) \]

(6) Establish evaluation model to get the fuzzy evaluation results \( B \).
\[ B = W \times R, B = (B_1, B_2, B_3 \ldots B_m) \]

(7) Determine the fuzzy evaluation assessment points \( M, M = B \times P^T \); \( P^T \) is transposed row vector \( P \).

### 4. Example

This paper based on a lot of previous experimental data and the experience of the laboratory teachers, taking a university cloud manufacturing experiment platform in Jiangsu as the research object and combined with the fuzzy evaluation model previously proposed, so that carry on a comprehensive evaluation on the various factors affecting the cloud manufacturing experimental platform flexibility to determine the evaluation level of the various influencing factors, namely the degree of influence cloud flexible. According to the influencing factors of cloud service composition flexibility shown in figure 2 to take a comprehensive evaluation, first of all need to evaluate each secondary index, and take tasks change as an example to show the calculation process.

(1) Determine the fuzzy evaluation factors set \( U_3 = (u_{31}, u_{32}, u_{33}, u_{34}) = (\text{suspension}, \text{requirements change}, \text{cancel}, \text{reset}) \); evaluation factors evaluation set \( V_3 = (v_{31}, v_{32}, v_{33}) = (\text{Stronger}, \text{strong}, \text{weak}) \). Assuming that the row vector as three grades \( P = (p_1, p_2, p_3) = (100, 80, 60) \).

(2) Using Delphi method to determine the weight matrix \( W_3 = (w_{31}, w_{32}, w_{33}, w_{34}) = (0.2, 0.3, 0.2, 0.3) \).

(3) On the basis of multiple sets of experimental data and expert evaluation results, evaluation of the factors as shown in table 1.

| Influencing Factors       | Stronger | Strong | Weak  |
|---------------------------|----------|--------|-------|
| Suspension                | 0.3      | 0.6    | 0.1   |
| Requirement Change        | 0.7      | 0.3    | 0     |
| Cancel                    | 0.3      | 0.5    | 0.2   |
| Reset                     | 0.6      | 0.3    | 0.1   |

Tasks change single factor evaluation matrix can be got by the above-mentioned:
\[ R_3 = \begin{bmatrix} 0.3 & 0.6 & 0.1 \\ 0.7 & 0.3 & 0 \\ 0.3 & 0.5 & 0.2 \\ 0.6 & 0.3 & 0.1 \end{bmatrix} \]

Tasks change comprehensive evaluation results:
\[ B_3 = W_3 \times R_3 \]
\[
= \begin{bmatrix}
0.3 & 0.6 & 0.1 \\
0.7 & 0.3 & 0 \\
0.3 & 0.5 & 0.2 \\
0.6 & 0.3 & 0.1
\end{bmatrix}
\]
\[
(0.2, 0.3, 0.2, 0.3) \times
\begin{bmatrix}
0.3 & 0.6 & 0.1 \\
0.7 & 0.3 & 0 \\
0.3 & 0.5 & 0.2 \\
0.6 & 0.3 & 0.1
\end{bmatrix}
= (0.51, 0.4, 0.09)
\]

Finally, we determine the fuzzy evaluation:
\[
M_3 = B_3 \times P^T = (0.51, 0.4, 0.09) \times (100, 80, 60)^T = 88.4
\]

Based on the same principle and steps, \(M_1 = 84\), \(M_2 = 77.4\), \(M_3 = 87.8\) can be calculated and the comprehensive evaluation points are shown in Table 2.

| First Index | RS | RSA | TC | QoS |
|-------------|----|-----|----|-----|
| Evaluation Points | 84 | 77.4 | 88.4 | 87.8 |

The points of resource service, service relationship, service quality evaluation and task change were 84, 77.4, 88.4, 87.8. Task changes lead to the greatest probability of failure in the cloud manufacturing system, that is, the influence factors related to task change are the most influential factors in manufacturing cloud service composition, which can be regarded as the key influencing factors. The impact of the change of the relationship among resource services on the flexibility of manufacturing cloud service composition is lower than the other factors, which can be regarded as a non key influencing factor. Therefore, in the application and management of cloud manufacturing service platform, in order to effectively prevent the cloud manufacturing system failure, timely and efficient manner to meet user needs, we must strengthen the monitoring and management of task changes related influencing factors, in uncertain factors, timely and effective feedback.

5. Conclusion
China's manufacturing industry is in a critical period of transformation and upgrading. In the process of transformation, resource constraints and idle resources puzzle the enterprises, so that resource hungry people are eager to get good resource support from outside through convenient and rented methods and people who are idle resources urgently need to improve the utilization of resources and realize the effective appreciation of their resources. In order to achieve the above requirements, it must pool global resources and optimize the allocation of resources. Cloud manufacturing is an advanced manufacturing model dedicated to bringing together and sharing manufacturing resources and manufacturing capabilities, and optimizing the allocation of resources.

In this paper, the multi-level fuzzy evaluation method is used to sum up the factors affecting organizational flexibility, and the mathematical model is established and empirical analysis is conducted. The empirical analysis finds out the key factors that affect the flexibility of the project organization, and analyzes and evaluates them according to the multi-level fuzzy comprehensive evaluation model, and finally draws the conclusion of the research. This research enriches the research content of organizational flexibility, adds new theoretical insights and opens up new research directions. It provides a feasible theoretical basis for the evaluation and measurement of project flexibility and its organizational flexibility.

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