Importance Analysis of Influencing Factors on Cloud Service Composition Flexibility from Service Provider Angle

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Abstract: The influencing factors of cloud service composition flexibility were analyzed from service provider angle; A Bayesian network model was built to analyze the importance of influencing factors on cloud service composition flexibility from service provider angle, and the critical and non-critical factors for the service provider were identified, which put the groundwork for the subsequently monitoring of the exceptional factors and the management of the flexibility of cloud service composition. Finally, use a shipbuilding enterprise which is constructing service platform for Cloud Manufacture as an example to conduct an application analysis.

Introduction

Cloud Manufacturing (CM) is a new model of manufacturing network which is highly-efficient and service-oriented[1]. In this model, service providers can put their unused manufacturing resource to the cloud pool in the form of cloud service. The operator of could manufacturing platform(CMP) then do centralized optimization management to them, and manufacturing task demanders can get their manufacturing service from the cloud pool directly[2-3]. The emergence of CM gives us a new way to achieve synergies of information and add the value of manufacturing resource.

Because the demands of manufacturing task demanders are becoming diversified, we need cloud service composition（CSC）to meet the task demands. In the whole life cycle of cloud service composition, there are many uncertain factors influencing the dynamic composition and execution of CSC, which will result in the failure of meeting the needs. In order to ensure the smooth and successful composition of cloud service, CSC should possess the ability of adjusting the composition schemes quickly and executing user demands successfully when uncertain influencing factors occur. It means CSC should have flexibility. This paper focuses on the analysis of influencing factors on cloud service composition flexibility（CSCF）and the importance analysis of these factors. Standing in the perspective of service provider, this paper will analyze and classify influencing factors on service composition flexibility. A Bayesian network model was built to do importance analysis of related influencing factors, and the critical and non-critical influencing factors on CSCF from service provider angle will be identified. This will put the groundwork for the subsequently monitoring of the exceptional factors and the management of the flexibility of cloud service composition.

Influencing Factors of CSCF from Service Provider Angle

Tao[4] pointed out that cloud service composition flexibility (CSCF) is the ability to response the external or internal dynamic changes in the life-cycle of cloud service composition (CSC), and the flow of CSC can be autonomously dynamic reconfigured to complete the tasks. The influencing factors on CSCF refer to all the related factors which will influence the capability of CSC to adjust composition schemes quickly and to execute the task demands successfully. Tao defined the life circle of cloud service composition with three phases, before implementation, in implementation, after implementation. They divided related influencing factors on CSCF into five categories: the change of resource service, the change of user demand, the change of quality of service, the change of application process and others. In fact, the way to categorize influencing factors on CSCF is comparatively unilateral. It did not do niche-targeting and detailed analysis on influencing factors on CSCF from the perspective of three basic role participants of CM. Zhu and other scholars[5-8] mentioned the conception of flexibility and influencing factors of flexibility, but they did not analyze influencing factors on CSCF in detail.

In the whole process of cloud manufacturing application service, there are three basic participant roles: service provider, operator of CMP and task demander. In the dynamic opening environment of CM, there are many abnormal conditions which can't be expected. In practical application, the reasons why three basic participant roles monitor influencing factors are not exactly the same, and the factors they pay special attention to are not exactly the same from their own angle. According to literature reading, investigation, expert experience, combined with the uncertainty and instability and other features of manufacturing cloud service composition, this paper deeply analyzed the influencing factors on CSCF from service provider angle. This paper divided the influencing factors on service composition flexibility which service providers pay special attention to in practical application into six categories: change of own resources(COR), change of other providers' resources(COPR), breakdown of could manufacturing platform(BCMP), post service evaluation from users(PSEU), change of task demanders' requirement(CTDR) and others. These factors are all influencing factors on CSCF from service provider angle, and to some extent they all prevent cloud manufacturing service platform from executing cloud service composition and accomplishing tasks with high efficiency and high quality. Fig.1 demonstrates influencing factors on cloud service composition flexibility from service provider angle.

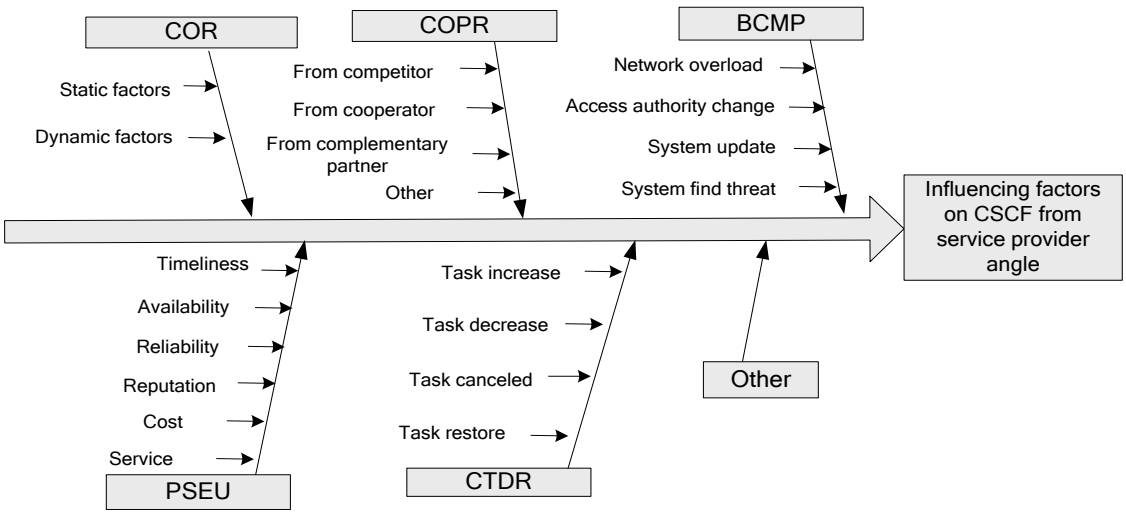

Figure 1.Influencing Factors from Service Provider Angle

There are many influencing factors on cloud service composition flexibility from service provider angle. In order to make it convenient for service provider to monitor flexible factors with target and high efficiency, it is necessary to analyze the importance of related flexible influencing factors, and proceed to identify the critical and non-critical factors form service provider. This would lay the foundation for the disposal of influencing factors on service composition flexibility and the management and elevation of flexibility.

Bayesian Network Model Constructing

Bayesian Network[9-10] (BN) is a mathematical model, which possesses the reasoning capability of uncertain information. The nodes represent variables and the directed line segments represent causal relationships between variables, and it uses conditional probability table to analyze quantitatively. Data from different sources are mix together in the form of priori information in order to decrease data requirements in the process of statistical analysis.

Bayesian Network Topology of Influencing Factors

When build a Bayesian network model, the paper assumes the influencing factors have mutual independence and do not influence each other. Based on the mentioned influencing factors on CSCF from service provider angle, a Bayesian network topology is constructed. Structure is as shown in Fig.2:

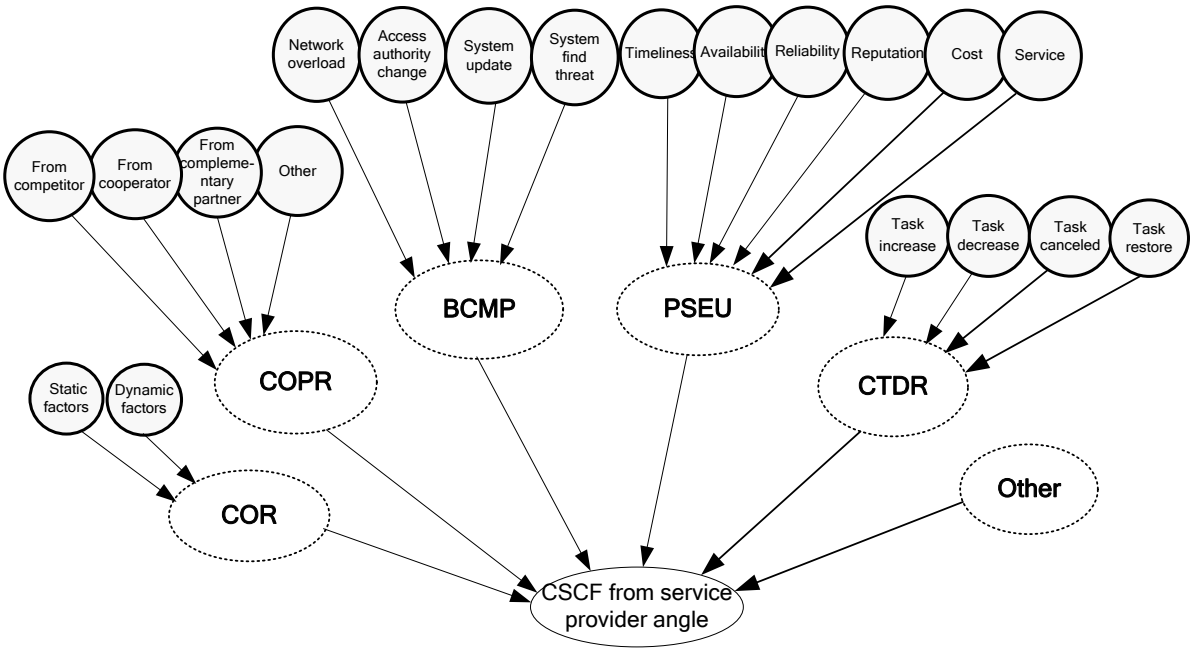

Figure 2.Bayesian Network Topology

Importance Analysis of Influencing Factors

When influencing factors occur, corresponding nodes need a short process of adjustment. Therefore, when the corresponding node is affected, we can assume that it is in a transient failure state. We set the condition of nodes with two statuses: safety (S) and failure (F). According to the statistical dates, we can know the probability value of each node; then we can calculate the probability of their parent nodes. The probability value expressed as percentage, the formula as follows:

$$W_{jT} = \prod_{i=1}^{n} \sigma_{iT} \quad (1)$$

$$W_{jF} = 1 - W_{jT} \quad (2)$$

In the formula, σ_{iT} represents the status of node *i* safety, W_{jT} represents the status of parent node *j* safety, W_{jF} represents the status of parent node *j* failure.

Bayesian network can do importance degree analysis of influencing factors on CSCF. The importance of influencing factors can be defined as:

$$D_i = (S_o - S_i) / S_o * 100\% \quad (3)$$

In the formula, Di represents the importance degree of factor *i*; S_o represents the incidence of parent nodes; S_i represents the incidence of parent node when factor *i* does not occur.

Case Analyses

This paper took Shipyard W in Nantong Jiangsu as the object of research. In the process of business operation, Shipyard W is the manufacturing could service provider. In the earlier stage, we investigated and collected all the information and data the company monitored and obtained in the process of business operation. On the basis of preliminary analysis, this paper screened and categorized influencing factors on manufacturing cloud service composition flexibility which it paid special attention for. The related statistical analysis data is demonstrated in Table 1.

Table 1 the Statistical Analysis

Influencing Factors Happened		Quantity	Percentage (%)	Failure Rate ($\times 10^{-4}$)	Note
COR	Static factors	324	13.65	0.893	COR fails 674 times, accounted for 28.39%, failure rate: 1.857 x 10^{-4}
	Dynamic factors	350	14.74	0.964	
	Competitor	210	8.85	0.579	COPR fails 423 times, accounted for 18.29%, failure rate: 1.196 x 10^{-4}
COPR	Cooperator	76	3.20	0.209	
	Complementary partner	125	5.27	0.345	
	Other	23	0.97	0.063	
	Network overload	69	2.91	0.190	BCMP fail 180 times, accounted for 7.59%, failure rate: 0.496 x 10^{-4}
BCMP	Access authority change	13	0.55	0.036	
	System update	28	1.18	0.077	
	System find threat	70	2.95	0.193	
	Timeliness	119	5.01	0.328	
	Availability	46	1.94	0.127	PESU fails 440 times, accounted for 18.53%, failure rate: 1.212 x 10^{-4}
PSEU	Reliability	65	2.74	0.179	
	Reputation	20	0.84	0.055	
	Cost	103	4.34	0.284	
	Service	87	3.66	0.239	

	Task increase	194	8.17	0.534	CTDR fails 499 times,
CTDR	Task decrease	186	7.83	0.512	accounted for 21.02%,
	Task canceled	68	2.86	0.187	failure rate: 1.374 x
	Task restore	51	2.15	0.141	10^{-4}
Other		147	6.19	0.405	others
SUM		2374		6.54	

According to the data in Table 1 and formula (1) and (2), we can calculate each node's probability of safety (T) and failure (F), the probability value expressed as percentage, the numbers belong to the same order of magnitude with the domestic and foreign related data statistics, so it is reasonable, as shown in Fig.3:

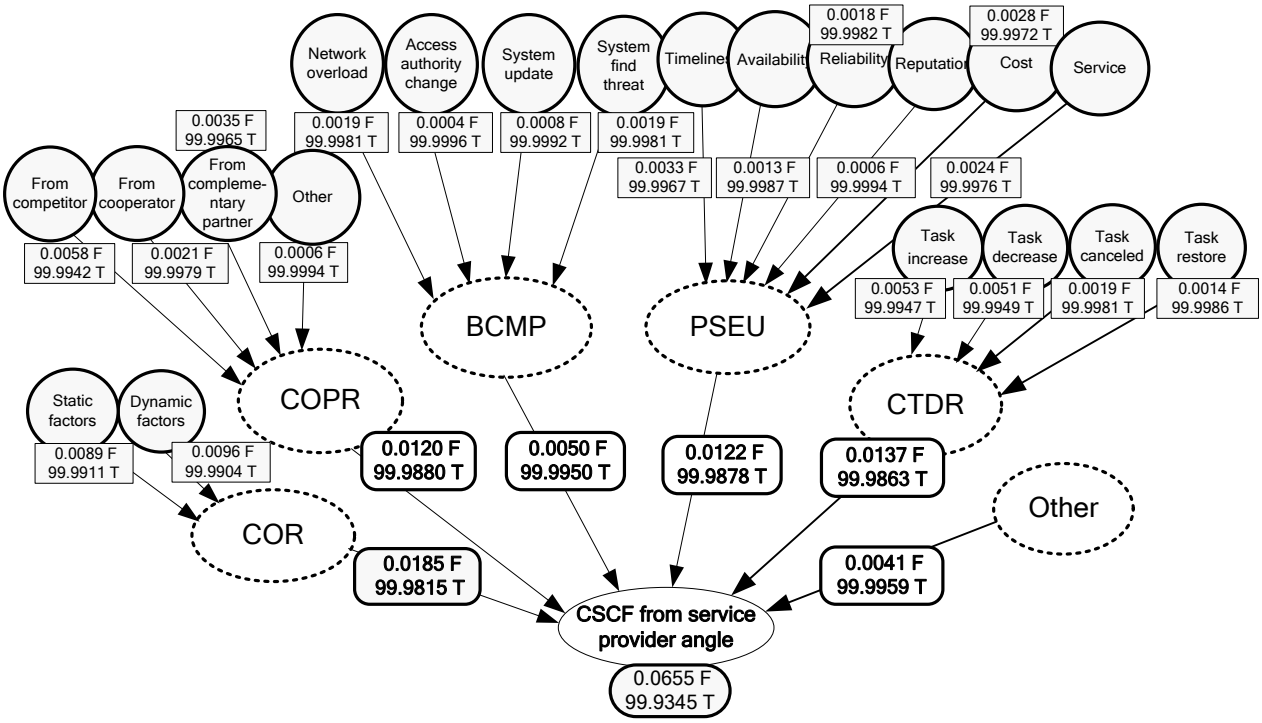

Figure. 3 Bayesian Network of CSCF from Service Provider Angle

Taking PSEU for example, we can calculate the safety probability of parent node is 99.9878%, and the probability of failure is 0.0122%. Similarly we can calculate the probability of other factors, and finally obtain the probability of CSCF from service provider angle failure is 6.55×10^{-4}.

In order to identify critical and uncritical influencing factors on CSCF for service provider, it is necessary to do importance analysis of each node. This paper took node "task increase" as an example. We need to reset its node status of failure (F) to 0, assuming that tasks did not increase. The model and the rest parameters are unchanged. According to the formula (1) and (2), the failure probability of CTDR falls to 0.84×10^{-4} from 1.37×10^{-4}, and the failure probability of CSCF from service provider angle falls to 6.02×10^{-4} from 6.55×10^{-4}. According to formula (3), we calculated the importance degree of node "task increase" is 8.09(The sum of all factors' importance degree is 100). Other factors' importance degree can be calculated in the same way, as shown in Fig.4:

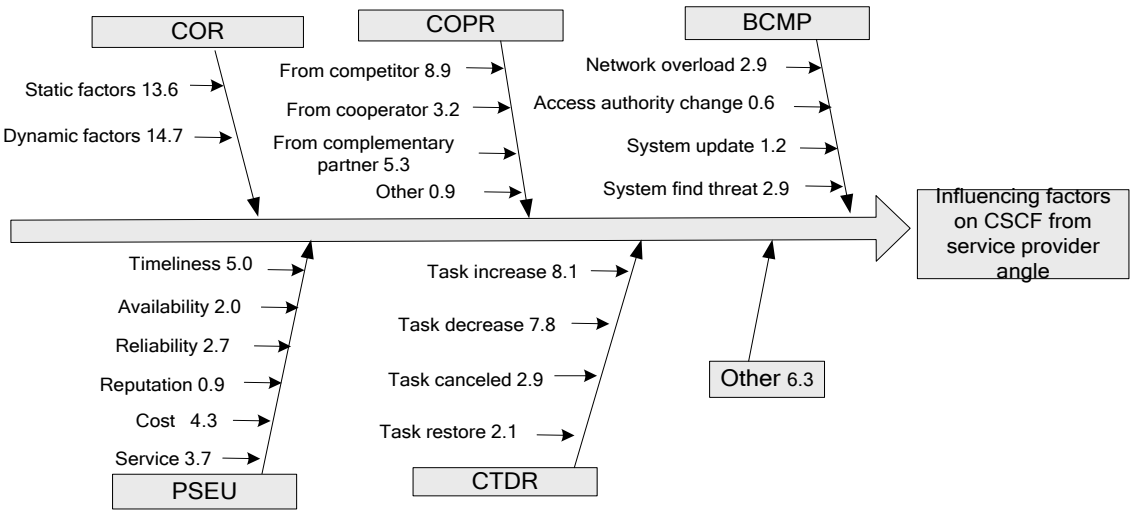

Figure. 4 Importance Degree of Influencing Factors

Fig.4 shows us, the importance degree of note “dynamic factors” is the maximum, and the importance degree of note “access authority change” is the minimum. Through further analysis, we find that the importance degree of influence factors related to COR factors is significantly higher than other factors, and BCMP is lower than others. Therefore, the influence factors related to COR can be defined as key factors, and related to BCMP can be defined as non-critical factors.

Conclusions

In this paper, the influencing factors of CSCF were analyzed deeply from service provider angle. A Bayesian network model was built to analyze the importance degree of influencing factors on CSCF from service provider angle, and the critical and non-critical factors for service provider were identified. We find that the importance degree of influence factors related to COR factors is significantly higher than other factors, and BCMP is lower than others. Therefore, the influence factors related to COR can be defined as key factors, and related to BCMP can be defined as non-critical factors. This will put the groundwork for the subsequently monitoring of the exceptional factors and the management of the flexibility of cloud service composition. Next, we are going to research the monitoring framework and mechanism of influencing factors on cloud service composition flexibility from service provider angle.

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