*Advances in Social Science, Education and Humanities Research (ASSEHR), volume 181*
4th International Conference on Social Science and Higher Education (ICSSHE 2018)

# *QoS Indicator System Design for Collaboration Oriented Web Service Composition*

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***Abstract*—In order to solve the problem of the dispersion and unity of the QoS (Quality of service), this paper builds a qualified web service composition QoS indicator system. Firstly, it mines deeply the SQoS indicators from the web service composition providers' view and the CQoS indicators from customers' view. Then, builds a collaboration oriented QoS indicator system. Finally, studies the evaluation model of the QoS indicator system. The QoS indicator system effectively unifies the SQoS indicators and CQoS indicators, realizes the integrity and interaction of the indicator system designing.**

***Keywords—Web Service Composition; Quality of Service; QoS Indicator System; Collaborative Management***

## I. INTRODUCTION

Web service composition (WSC) integrates services from different independent service vendors. With the increasing number of web services, the non-functional property (QoS) of the services is always weighed by consumers. Due to customers' different preferences for QoS, QoS has become an important factor to measure whether the web service composition has met customers' demands [1].

Currently, QoS indicators have been different analyzed by many researchers. Some consider that QoS has combined different service features and service properties, such as availability, confidentiality and response time [2], others study web service selection method by making QoS optimal objective [3], or establish a dynamic QoS query optimization model to achieve a multi-level matching QoS indicators [4]. Some divide QoS attributes into the positive and negative types [5], and others believe that QoS indicators of image processing service including response time, availability, reliability, resolution or color depth [6], or propose dynamic QoS attributes [7] and give QoS models [8,9].

However, there are following four main deficiencies. (1) QoS indicator system is not completely uniform. (2) The functional attributes and non-functional attributes of web service are conceptual confusion. (3) The online QoS and offline QoS are not achieve effective mapping. (4) Different subjects are on different QoS indicators bias.

For the above deficiencies, this paper mines the SQoS indicators and the CQoS indicators, and on this basis, builds a QoS indicator system for Collaboration and studies the evaluation model of the QoS indicator system.

This work has been funded by the Colleges and Universities Outstanding Youth and Middle Aged Scientific and Technological Innovation Team Project of Hubei Province (No.T201628)

## II. QOS INDICATOR SYSTEM ORIENTED CUSTOMERS AND SUPPLIERS

Due to the collaboration exists between the customer and the WSC provider, this section focuses on analysis the QoS indicators of customer and supplier perspective.

### *A. QoS indicator system oriented customers*

When customers select WCS providers, they will more consider their own interests. Customer-oriented QoS indicators (CQoS) include functionality, price, security, credibility, reliability, convenience and empathy; they constitute CQoS indicator system for the customer, as shown in Fig. 1.

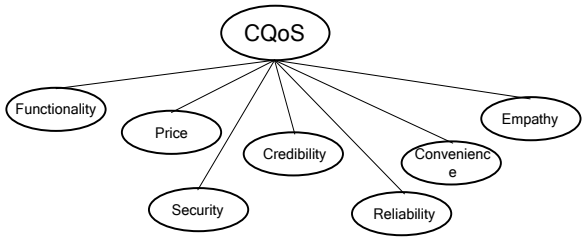


Fig. 1. QoS indicator system oriented Customers

### *B. QoS indicator system oriented suppliers*

When suppliers provide WSC, they will more consider how to get higher profits. Supplier-oriented QoS indicators (SQoS) include frequency, cost, scalability, loyalty, availability, integrity and interactivity, they constitute SQoS indicator system for the supplier, as shown in Fig. 2.

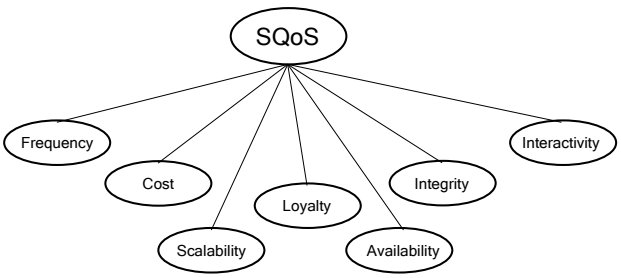


Fig. 2. QoS indicator system oriented suppliers

## III. CONSTRUCTION OF QOS INDICATOR SYSTEM

The CQoS and SQoS indicator systems established in the previous section have reflected the needs of customers and suppliers. However, we can't put two different indicator systems as the QoS indicator system of WSC. Therefore, a set of QoS indicator system for collaboration to reflect the QoS requirements of both customers and suppliers must be studied. This section constructs a three-layer QoS indicator system for collaboration, in which the first layer is the overall QoS of WSC, the second layer are economic indicators, website performance indicators, customer service indicators and customer feedback indicators. The indicator system sets up 3 layers which are including 14 variables. The basis of the collection of each indicator data and the acquisition of each indicator value are as follows:

### *A. Economic indicators*

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

*1) Cost of WSC*

It includes the costs for communicating and building partnerships between web service integrators (WSIs) and independent service providers (ISVs), cooperating with partners in the technology and programs, integrating and consolidating the web services, improving CQoS for attracting customers, and improving the competitiveness of WSC, etc. These data can be integrated from the suppliers' financial statements. Under the same conditions as profitability, the lower the cost of WSC, the stronger coordination ability of WSI. The formula is as follows:

$$Q_{cost} = Q_{relationships} + Q_{cooperation} + Q_{Integration} + Q_{Improvement} \quad (1)$$

In above formula, $Q_{cost}$ represents the cost of WSC, $Q_{relationships}$ represents the costs for communicating and building partnerships between web service integrators (WSIs) and independent service providers (ISVs), $Q_{cooperation}$ represents the costs for cooperating with partners in the technology and programs, $Q_{Integration}$ represents the costs for integrating and consolidating the web services, $Q_{Improvement}$ represents the costs for improving the competitiveness of WSC.

*2) Price of WSC*

Price of WSC is the expense that customers need to pay for the purchase of WSC. The formula is as follows:

$$Q_{price} = P \times P_{dis} \quad (2)$$

In above formula, $Q_{price}$ represents the price of WSC, $P$ represents the bid of WSC, $P_{dis}$ represents the discount of WSC.

### *B. Website performance indicators*

*1) Response time*

It includes the operation time that processes and completes customers' requests, and the time consuming during the transmission of the requests. The formula is as follows:

$$T_{\text{Response}} = T_{\text{execution}} + T_{trasmiaaion} \quad (3)$$

In above formula, $T_{\text{Response}}$ represents response time, $T_{\text{execution}}$ represents the operation time that processes and completes customers' requests, $T_{trasmiaaion}$ represents the time consuming during the transmission of the requests.

*2) Reputation*

Reputation is the level of trust between customers and the website that provides WSC. It uses the results of the comprehensive evaluation of visibility and overall impression of the website to measure. The formula is:

$$Q_{\text{Reputation}} = \frac{\sum_{i=1}^{N} (Score1_i + Score2_i)/2}{N} \quad (4)$$

In above formula, $Q_{\text{Reputation}}$ represents reputation, $score1_i$ represents the visibility score of the website that customer $i$ provides, $score2_i$ represents the website overall impression score that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score1_i \in [0,1], score2_i \in [0,1]$.

*3) Success rate*

Success rate is the probability of correct responses. It is decided by the number of successful implementation of WSC and the total number of requests. The formula is:

$$Q_{\text{Success}} = R_{\text{Success}} / N \quad (5)$$

In above formula, $Q_{\text{Success}}$ represents success rate, $R_{\text{Success}}$ represents the number of successful implementation of WSC, $N$ represents the total number of requests.

*4) Availability*

Availability is the time ratio of web services are used immediately. It reflects the probability of being successfully invoked web services. The formula is:

$$Q_{\text{Availability}} = \frac{T_{\text{uptime}}}{T_{\text{uptime}} + T_{\text{downtime}}} \times 100\% \quad (6)$$

In above formula, $Q_{\text{Availability}}$ represents availability, $T_{\text{uptime}}$ represents normal continuous operation time under the premise of service does not fail, $T_{\text{downtime}}$ represents the stop running time.

*5) Convenience*

Convenience is the degree of convenience and ease of the website. It is also the result of a comprehensive evaluation by customers. The formula is:

$$Q_{\text{Convenience}} = \frac{\sum_{i=1}^{N} score_{i1}}{N} \quad (7)$$

In above formula, $Q_{Convenience}$ represents convenience, $score_{i1}$ represents the convenience score of the website that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score_{i1} \in [0,1]$.

### C. Customer service indicators

*1) Security*

Security is the ability of WSI and Web server to exclude potentially dangerous for customers. The formula is:

$$Q_{\text{Security}} = \frac{\sum_{i=1}^{N} (Score3_i + Score4_i)/2}{N} \quad (8)$$

In above formula, $Q_{\text{Security}}$ represents security, $score3_i$ represents the risk score of service that customer $i$ provides, $score4_i$ represents the privacy score of service that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score3_i \in [0,1]$, $score4_i \in [0,1]$.

*2) Empathy*

Empathy is the human caring extent that the WSI gives to customers. The formula is:

$$Q_{\text{Empathy}} = \frac{\sum_{i=1}^{N} (Score5_i + Score6_i + Score7_i)/3}{N} \quad (9)$$

In above formula, $Q_{\text{Empathy}}$ represents empathy, $score5_i$ represents the personalized score of service that customer $i$ provides, $score6_i$ represents the compensatory score of service that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score5_i \in [0,1]$, $score6_i \in [0,1]$, $score7_i \in [0,1]$.

*3) Reaction speed*

Reaction speed is the time during sending and response the requests in the WSC pre-sale, sale and after-sales process. It can be done statistics directly by WSI.

*4) Waiting time*

Waiting time is the waiting time when actual consumption. It may be done statistics directly by service providers.

### D. Customer feedback indicators

*1) Satisfaction*

Satisfaction is the matching degree of customer expectations and actual customer experience. Its value can be obtained by comprehensive evaluation by customers. The formula is:

$$Q_{\text{Satisfaction}} = \frac{\sum_{i=1}^{N} score_{i2}}{N} \quad (10)$$

In above formula, $Q_{\text{Satisfaction}}$ represents satisfaction, $score_{i2}$ represents the satisfaction score of service that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score_{i2} \in [0,1]$.

*2) Consistency*

Consistency is the matching degree of the described function and actual function. The value also can be obtained by comprehensive evaluation by customers. The formula is:

$$Q_{\text{Consistency}} = \frac{\sum_{i=1}^{N} score_{i3}}{N} \quad (11)$$

In above formula, $Q_{\text{Consistency}}$ represents consistency, $score_{i3}$ represents the consistency score of service that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score_{i3} \in [0,1]$.

*3) Rationality*

Rationality is the personal perception whether the cost in line with its level of value. The value also can be obtained by comprehensive evaluation by customers. The formula is:

$$Q_{\text{Rationality}} = \frac{\sum_{i=1}^{N} score_{i4}}{N} \quad (12)$$

In above formula, $Q_{\text{Rationality}}$ represents rationality, $score_{i4}$ represents the rationality score of service that customer $i$ provides, $N$ represents the total number of the customers that provide the scores, $score_{i4} \in [0,1]$.

## IV. FUZZY COMPREHENSIVE EVALUATION OF QOS INDICATOR SYSTEM

### A. Construction of Multistage dynamic fuzzy comprehensive evaluation model

According to QoS Indicator system of Collaboration Oriented WSC, a set of three fuzzy comprehensive evaluation as follows:

*1) Comprehensive QoS evaluation indicator of WSC*

$Q = \{E, W, S, F\}$, $E$ represents economic indicators, $W$ represents website performance indicators, $S$ represents customer service indicators, $F$ represents customer feedback indicators.

*2) Economic indicators*

$E = \{E_1, E_2\}$, $E_1$ represents cost of WSC, $E_2$ represents price of WSC.

*3) Website performance indicators*

$W = \{W_1, W_2, W_3, W_4, W_5\}$, $W_1$ represents response time, $W_2$ represents reputation, $W_3$ represents success rate, $W_4$ represents availability, $W_5$ represents convenience.

*4) Customer service indicators*

$S=\{S_1,S_2,S_3,S_4\}$ , $S_1$ represents security, $S_2$ represents empathy, $S_3$ represents reaction speed, $S_4$ represents waiting time.

*5) Customer feedback indicators*

$F=\{F_1,F_2,F_3\}$ , $F_1$ represents satisfaction, $F_2$ represents consistency, $F_3$ represents rationality.

### *B. Dimensionless process for QoS indicators*

Firstly, a QoS evaluation set $V=\{V_1,V_2,V_3,V_4,V_5\}$ is created and we use five levels of evaluation set such as very good($V_1$), good($V_2$), normal ($V_3$), poor($V_4$), very poor($V_5$).

Then, we use membership function to make dimensionless process for positive and reverse indicators. By the actual value $x_k$ of each indicator, we get the original value $x_k$ of the $k$ item, use the following fuzzy quantification models to make dimensionless process for positive and reverse indicators by the maximum score $x_{k\max}$ and minimum score $x_{k\min}$, and convert the original value into the dimensionless value $Q(x)$. The models are:

*1) Positive indicators fuzzy quantification model*

Positive indicator can lead to the progressive increasing of the QoS indicator when it ascends. In this paper, it includes reputation, success rate, availability, convenience, security, empathy, satisfaction, consistency and rationality. The formula is:

$$Q(x)=\begin{cases}0 & x\le x_{k\min}\\ \frac{1}{2}+\frac{1}{2}\sin\frac{\pi}{x_{k\max}-x_{k\min}}(x_k-\frac{x_{k\max}+x_{k\min}}{2}) & x_{k\min}<x<x_{k\max}\\ 1 & x\ge x_{k\max}\end{cases} \quad (13)$$

*2) Reverse indicators fuzzy quantification model*

Reverse indicators can lead to the progressive decreasing of the QoS indicator when itself ascends. In this paper, it includes cost of WSC, price of WSC, response time, reaction speed and waiting time. The formula is:

$$Q(x)=\begin{cases}1 & x\le x_{k\min}\\ \frac{1}{2}-\frac{1}{2}\sin\frac{\pi}{x_{k\max}-x_{k\min}}(x_k-\frac{x_{k\max}+x_{k\min}}{2}) & x_{k\min}<x<x_{k\max}\\ 0 & x\ge x_{k\max}\end{cases} \quad (14)$$

We use the above formula to make dimensionless process for all indicators, then, separately calculate the membership of indicator level according to the following formula.

The evaluation level of membership of the positive indicators is calculated as:

$\alpha_1(\mu)=e^{-25(q-0/4)(q-0/4)\ln 2}$, $\alpha_2(\mu)=e^{-25(q-1/4)(q-1/4)\ln 2}$,
$\alpha_3(\mu)=e^{-25(q-2/4)(q-2/4)\ln 2}$, $\alpha_4(\mu)=e^{-25(q-3/4)(q-3/4)\ln 2}$,
$\alpha_5(\mu)=e^{-25(q-4/4)(q-4/4)\ln 2}$.

The evaluation level of membership of the reverse indicators is calculated as:

$\alpha_1(\mu)=e^{-25(q-4/4)(q-4/4)\ln 2}$, $\alpha_2(\mu)=e^{-25(q-3/4)(q-3/4)\ln 2}$,
$\alpha_3(\mu)=e^{-25(q-2/4)(q-2/4)\ln 2}$, $\alpha_4(\mu)=e^{-25(q-1/4)(q-1/4)\ln 2}$,
$\alpha_5(\mu)=e^{-25(q-0/4)(q-0/4)\ln 2}$.

In above formula, $q$ represents the dimensionless values for each indicator. Then obtain quantitative calculated results of each indicator of the calculated membership functions by normalization process.

## V. CONCLUSION

This paper has analyzed and designed QoS indicator system of collaboration oriented web service composition. However, in practice, some indicators in the above QoS indicator system may be small influence on the customers to choose the web service composition. Therefore, we should also dig out the key indicators which will also be analyzed in the next step.

## ACKNOWLEDGMENT

This work has been funded by Humanities and social science research project in Hubei province (No.18G057).

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