Service-Oriented Business Process Modeling and Performance Evaluation based on AHP and Simulation

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Abstract

With the evolution of Grid technologies and the application of Service-Oriented Architecture (SOA), more and more enterprises are integrated and collaborated with each other in a loosely coupled environment. A business process in that environment, i.e., the Service-Oriented Business Process (SOBP), shows highly flexibility for its free selection and composition of different services. The performance of the business process usually has to be evaluated and predicted before its being implemented. And it has special features since it includes both business-level and IT-level attributes. However, the existing modeling and performance evaluation methods of business process are mainly concentrated on business-level performance. And the researches on service selection and composition are usually limited to the IT-level metrics. An extended activity-network-based SOBP Model, its three-level performance metrics, and the corresponding calculation algorithm are proposed to fulfill these requirements. The advantages of our method in SOBP modeling and performance evaluation are highlighted also.

1. Introduction

Grid technologies and Service-Oriented Architecture (SOA) have developed quickly and applied broadly to a degree maturity in recent years [1]. With the widely use of services in the new service-oriented computing environment, it is important to obtain a high performance Service-Oriented Business Process (SOBP) with loosely coupled services.

Because of the distinctive characteristics of the service [1], SOBP's performance includes two distinctive kinds of performance metrics. Some of them assess the business-level performance, the others assess the IT-levels, and they are associated with each other closely within a service.

So a new performance evaluation method combined with both the business-level and IT-level attributes of SOBP is needed earnestly. And the method will be used not only to decide the service selection and composition such as [2][3][4][5], but also to assess the suitability about the services selected with the resources, organization structures, business rules, and other activities of the enterprise to which the SOBP belongs.

However, the researches of [6]-[10] on service selection and composition based on Quality of Service (QoS) were focused on the IT-attributes mainly and often neglected the business performance being impacted by the services selected. For example, [10] proposed the QoS such as service price, time, reputation, availability, successful rate, and relations among services. But its evaluation almost not concerned with the resources, organization structure, and so on of the enterprise to which it will be used.

And the traditional performance evaluations of business process ([11]-[15]) were usually concentrated on the business -attributes only. Business process indexes of Balanced Score Card comprise product demand rate, product sale rate, production flexibility, and order advance [11]. Process performance metrics of SCOR includes reliability, responsiveness, flexibility, cost, and assets [12]. And [13][14][15] analyzed the performance attributes of time, ratio of resources utilization, and cost. They evaluated the business –process's performance without considering the IT-attributes at all.

Reference [6] proposed a simulation-oriented workflow model and with which the simulation engine would calculate parameters predefined in it at the build-time of modeling. And [16] has developed an interactive-event-based workflow simulation in service-oriented computing environment. But they did not deal with the modeling and performance evaluation of SOBP.

In order to address the above issues, we will propose a comprehensive performance metrics with corresponding calculation algorithm that can be implemented by system simulation in this paper. Our main contribution is that, with profound analyses on the service-oriented process modeling and its performance metrics correlations among service, SOBP, and enterprise, we made a AHP and simulation-based performance evaluation method applicable to evaluating performance of business process in a loosely coupled environment like that of service-oriented computing.

The rest of the paper is organized as follows. We analyze the performance attributes of service and SOBP and their modeling method in section 2, and propose their performance metrics in section 3, the corresponding AHP-simulation-based calculation algorithm is presented in section 4 and a full case is illustrated in section 5. Finally, conclusions and promising future work are given in section 6.

2. New features and modeling of service-oriented business process

Service-oriented business process (SOBP) in this paper means a process that may not only comprise all traditional process elements but also the networked-service (NS) additionally. NS here denotes a service that has implemented a certain business-process-function and has been capsulated and published on network.

2.1. Classification of activities in SOBP

A model of SOBP based on the extended activity-network is illustrated in Fig.1, and the activities of SOBP are classified into three subclasses according to their different implementation mechanisms. The manual-activity (MA) means an activity completed by human being (of course he or she can fulfill the activity by using resources including IT systems); and the NS-activity (NSA) represents an activity that is implemented by NS; if an activity is implemented by an enterprise application system and the system is not a NS, then it is an application-system-activity (ASA).

NS can be divided into three subclasses by its correlation to the enterprise to where it will be used. Some of the NS, i.e., the inner-NS, are deployed within the enterprise and just used by the enterprise itself, and the others come from the external enterprises. Some of the external enterprises' NS have been tested or used (the tested-NS) before by the enterprise, such as a service of a partner, and they are trustier than the other external NS (the external-NS). Obviously all the external-NS to be used has to be tested or simulated firstly. The relations between business and IT can be depicted clearly by the above classifications which are helpful to the modeling of SOBP.

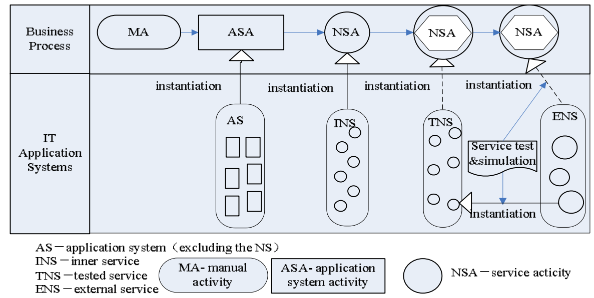

Fig.1. Relations between IT application and business process

Consequently, the modeling process of SOBP would comprise three steps:

Step 1: To construct the abstract-process that includes some abstract service (ASV);

Step 2: Every ASV will select some candidate physical service (PSV) from UDDI according to the predefined matching algorithms. And the PSVs of an ASV will be ordered by some criteria.

Step 3: Select just only one PSV for each ASV, and compose all the selected PSVs with other activities of the abstract-process to form a complete SOBP.

2.2. The Position of SOBP in Performance Analysis of an Enterprise

Generally speaking, the performance of an enterprise can be analyzed with top-down method and evaluated with the bottom-up one, and the higher-level performance includes or reflects the lowers in principle. Here we will explore the position of SOBP in the performance analysis of an enterprise extensively and deeply (see Fig.2).

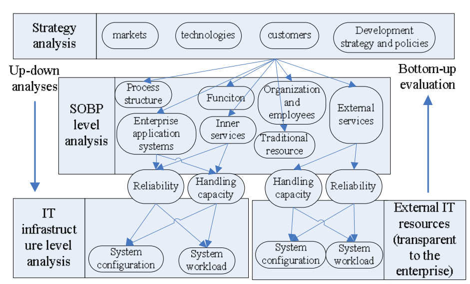

Fig.2. SOBP's position in the performance analysis of Enterprise

Enterprise strategy analysis is the high-level performance analysis of SOBP. It is time to carry out the enterprise strategy analysis when global decisions of the enterprise-wide re-engineering of business processes or information planning have to be made.

The development strategy, policy, and strategy positioning of an enterprise will be analyzed macroscopically from the aspects of market trends, customers' requirements, development of technologies, and the current situation of the enterprise itself at first. Then the strategy positioning will be divided into highly ordered strategy topics, and the corresponding activities are to be customized to implement them.

Thus, the strategy performance metrics (e.g., compete advantages, financial performance, etc.) can be divided and attached to the performance of the functions, structures, organizations, resources, sub-processes, activities, products, services, and the support systems (e.g., the enterprise application systems) of SOBP. On the contrary, the performance metrics of SOBP will be combined to evaluate the business performance of the strategy level.

The IT infrastructure's performance analysis is mainly focused on the performance of computer systems and their impacts on SOBP. Performance of computer systems usually comprise its reliabilities (or availabilities), and processing capacities (e.g., various throughput, response time, and so on). Their major influence factors include the workload and configuration of the systems.

Since both the application-system and NS of SOBP can be deemed as a computer system, the performance analyzed at the infrastructure-level can be combined to become a part of the performance of SOBP at last. Thus it can be seen, SOBP is a connecting link between the strategy performance and the infrastructure performance in the performance analysis of an enterprise. And the performance of SOBP reflects the performance of the strategies and IT infrastructures of the enterprise.

2.3. The service-viewpoint of SOBP

As show in Fig.3, the service-viewpoint investigates the correlation of business and IT in service-oriented enterprise extensively from different abstract levels (i.e., strategy and business, IT system [17][18], and IT infrastructure [19] levels), different stakeholders (e.g., enterprise owner, planner, architect, constructor, etc.), and different concerns. The concept of service here is generalized [20] and not limit to the NS.

The range of the abstract levels concerned by different stakeholders is different. For example, the customers and business operators concern the strategy and business levels; the maintainers of IT infrastructure just concern the IT issues of computer network and data; but the planners and architects of business and IT concern all the abstract levels and their relations.

Furthermore, different stakeholders at the same abstract level may have different concerns also. Business operators concern compete advantages and marketing position of the enterprise, so they obtain the perspective of enterprise types such as the product type, the traditional service type, and the contemporary service type. But business managers and analyzers concern whether an activity of SOBP can be implemented by application system, the inner-NS, or the external-NS.

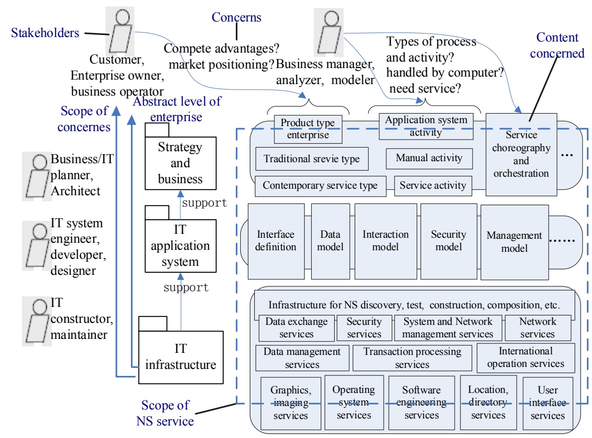

Fig.3. SOBP's service-viewpoint

2.4. The attributes levels of NS

It can be seen from Fig.3 that NS is related to all the abstract levels of service-oriented enterprise. Consequently, the performance of NS comprises three-level attributes:

Level1: business-level attributes (business-attributes) —here NS is looked as an activity that fulfills the objectives of the business operation and strategy, and business-attributes describe the function and performance of the activity.

Level2: application-system-level attributes (application attributes) —here NS is looked as an application system that implements the function of an activity. Application-attributes describe not only the activity's relation to the application system but also the performance of the application system from the IT perspective when an ASV matching with PSVs and the composing of PSVs, application-system-activities, and manual-activities.

Level3: IT-infrastructure-level attributes (technology- attributes) –here NS is considered as a concrete computer system, and technology-attributes describes the relation between the system's function and performance with the IT infrastructure such as software, hardware, network, etc.

3. SOBP's performance metrics

The metrics of NS selected here can be extended with other metrics at each level, but its structure is stable. And the three-level metrics of NS are associated closely. The technology-attributes are the foundation of application-attributes and business-attributes, and so do the application- attributes to the business-attributes.

3.1. The business-level metrics

1) Business reliability/business risk (*Reli busi*)

$Reli_{busi}$ denotes the reliability of business performance promised by service providers, where $Reli_{busi}=(1-Risk_{busi}) \in (0,1]$, $Risk_{busi}=(\sum|x_{pi}-x_{ri}|/x_{pi})/n$; x_{pi} is the promised value of metrics provided by the service providers and x_{ri} is the real value of the metrics that can be ascertained with the assessments provided by n consumers.

2) Business time($Time_{busi}$)

$Time_{busi}$ denotes the completing time of a business promised by service providers. It's issued by providers and may be an interval such as 2-5 days.

3) Business cost ($Cost_{busi}$)

$Cost_{busi}$ denotes the business cost promised and issued by service providers. It may be an interval such as ＄200-500.

4) Business flexibility ($Flex_{busi}$)

$Flex_{busi}=Ffun \otimes Fperf$ denotes the business flexibility, where *Ffun* denotes the number of NS's optional implementation schemes with the same function, e.g., the function named TRANSPORTATION may be implemented by train, car, or plane, then F_{fun}=3; and *Fperf* denotes the number of optional performance schemes of a certain function scheme, e.g., the function scheme named BY TRAIN has the performance schemes as below: 10 days, ＄100; and 1 day, ＄500, so *Fperf*=2; "$\otimes$" here indicates the number of combinatory function schemes and performance schemes.

5) Business organization relationship ($Org_{relation}$)

$Org_{relation} \in (0,1]$ denotes the business organization relationship between SOBP and its service providers at business level; for the inner-NS the value is 1. It is used to weigh the correlation of different enterprises at business level.

3.2. The application-level metrics

6) System response time (*Qtime*)

$Qtime=\sum_1^n Qtime_i/n,\ i=1\ldots n,$ denotes the time span between the times when the system receives an input and output the corresponding outcomes which can be predicted by the existing records.

7) System availability (*Qavail*)

Qavail=Tsucc/Ttotol denotes the time ratio that a service can be available successfully (*Tsucc*) in an interval (*Ttotal*). SUCCESS here means the service having returned a correct output in an expected interval.

8) System organization relationship

$Qorg_{relation} \in (0,1]$ denotes the organization relation between the SOBP and its service providers from the IT perspective. It can be used to weigh the collaboration relations among different enterprises' application systems.

9) System flexibility

$Qflex=f(Flex_{busi})$ denotes system's flexibility that is related to the implementation technologies of a service such as its function and interfaces descriptions and so on. It is the technology-base of the metrics $Flex_{busi}$.

10) System throughput

Qthrou=N/Ttotal denotes the transactions handled by a service in a unit time.

3.3. The IT-infrastructure-level metrics

11) IT component reliability

ITreli=Twork/Ttotal denotes the ratio of the time span of a component working correctly (*Twork*) in a given interval (*Ttotal*).

12) IT resources utilization

ITutili=Tuse/Ttotal denotes the ratio of time that a component being used (*Tuse*) in a given interval (*Ttotal*).

13) System configuration and structure

$ITconfig \in (0,1]$ denotes the comprehensive evaluation of the system's structures, scheduling policies, work patterns and so on. It can be analyzed by quality analysis methods, benchmarking method, etc.

According to the analyses in section 3, the performance metrics of SOBP are mainly decided by the metrics of NS. And the performance metrics of SOBP may cover the five business-attributes of NS, i.e., Business *Time (T), Cost (C), Reliability (R), Flexibility (F),* and *Organization relations (O)* between SOBP and its activities (including the services selected).

Furthermore, the performance evaluation of SOBP can be used to measure and optimize the application-level and IT-infrastructure-level metrics of an inner-NS. But as a consumer, SOBP just proposes its requirements of the application-level metrics and it is not concerned about the IT-infrastructure-level metrics of the external-NS since they are transparent to the SOBP.

4. SOBP's performance calculation based on AHP and simulaiton

We extend the simulation system based on [6][15][21] with the method proposed in this paper. An simulation system named CIMFLow[21] is a modeling and simulation tool based on multiple-views (i.e., the views of process, organization, resources, employees, etc.) of enterprise. A simulation model with multiple views and corresponding parameters of the model elements should be constructed firstly, then the model will be executed by the simulation engine, and the required data can be obtained at the end of the simulation.

Since CIMFlow has had the function to run workflow simulation models already, the main tasks for performance calculation of SOBP based on AHP and simulation are to: (1) supplement parameters to the existing process elements for the performance metrics such as the business reliability, business flexibility, business organization relationship and so on; (2) add a modeling element for NS, and all its metrics should be set as parameters of the element; (3) incorporate the calculation algorithm into CIMFlow.

The performance metrics calculation methods comprise three parts mainly as blow:

4.1. The AHP-based comprehensive performance calculation

Step1: determine the performance metrics set of NS

Each metrics in section III can be assigned a serial-number k and corresponding weight w_k, $k=1,...,K$, K is the number of all metrics selected by users.

And assume a SOBP has n activities, m of them are *NS-activities* (i.e., *ASVs*), and each *ASVi*, $i=1,...,m$, has p_i *PSVj*, $j=1,..., p_i$. Thus, the performance of *ASVi*, P_i, is a two-dimensional matrix:

$$P_i = (P_{i,j}^k; 1 \le j \le p_i, 1 \le k \le K) \tag{1}$$

And the performance of the jth PSV_j, P_{ij}, is a vector:

$$P_{i,j} = (P_{i,j}^k; 1 \le k \le K) \tag{2}$$

Similarly, the performance of manual-activities and application-system-activities can be denoted as a vector also:

$$P_i = (P_i^k; 1 \le k \le \overline{K}) \tag{3}$$

Where $\overline{K}$ is the number of performance metrics of the manual-activity or application-system-activity.

Step2: determine the weights of all metrics based on AHP

Compare the metrics' importance one by one and give a value to each of them, then set up the judgment matrix A and solve it to get the weights set W. If the calculation coherence of W can be verified, the W is the needing weights vector.

Step3: determine the fuzzy relation and fuzzy comprehensive evaluation model

Firstly we can get a fuzzy remarks set V with elements v_l, l=1,…,m; then the remarks of each metrics in (2) can be denoted r_{kl}. So we get the fuzzy relation matrix R from P_{ij} to V:

$$R = \{r_{kl}, 1 \le k \le K, \quad 1 \le l \le m\} \tag{4}$$

According to the value of $B=WR=\{b_1,...,b_m\}$, we can arrange the order of all the *ASVi*'s *PSVs*. If we just select the anterior *Ui*, *Ui=1,...,p*$_i$, PSV_{ij}s as the candidates of *ASVi*, the potential composition schemes of a SOBP should be N. Regardless to that a certain *ASVi* may select several *PSVi,ui* ($1 \leqslant u_i \leqslant U_i$) with different probabilities at one time, N will be:

$$N = \prod_{i=1}^{m} U_i \tag{5}$$

4.2. Performance equivalent calculation

Obviously, the performance of SOBP is involved in its activities' structures. Usually, there are four types of structures such as sequential, concurrent, alternative with probabilities, and iterative structures. The iterative structure can be transformed to the former three types, so just the former-three-type structures' performance-equivalent-calculation methods are shown below.

Each composition scheme of (5) is denoted as *SOBPs, s=1,...,N.* Let *SOBPs* has n activities, *Ai*, $1 \le i \le n$; P_i^k represent the kth performance metrics of *Ai*; v_i be the given implementation probability of *Ai* that belongs to the alternative structure and $\sum v_i=1$.

Let O_i denote the organization *of Ai*, OR_{ij} represent the relationship between O_i and O_j, then all the relationship between any two activities of a SOBP can be denoted as a matrix $OR=(OR_{ij})m \times n$. Thus the organization relation of *Ai* in SOBP is as below:

$$P_i^5 = \prod_{j=1}^{n} OR_{ij} \tag{6}$$

Thus, all the performance equivalent calculation methods can be shown as below:

(Ⅰ) When the n activities are concurrent, the kth performance of *SOBPs* (P_s^k) can be calculated by:

$$P_s^k = \begin{cases} \min_{i=1}^{n}\{P_i^k\}, & k=1; \\ \max_{i=1}^{n}\{P_i^k\}, & k=2; \\ \sum_{i=1}^{n} P_i^k, & k=3; \\ \prod_{i=1}^{n} P_i^k, & k=4; \\ \sum_{i=1}^{n} P_i^k \Big/ n, & k=5. \end{cases} \tag{7}$$

(Ⅱ) when the n activities are alternative, the kth performance of *SOBPs* (P_s^k) can be calculated by:

$$P_s^k = \sum_{i=1}^{n} v_i P_i^k,\ k = 1,2,3,4,5. \tag{8}$$

(Ⅲ) And when the n activities are sequential, the kth performance of *SOBPs* , P_s^k, can be calculated by:

$$P_s^k = \begin{cases} \prod_{1}^{n} P_i^k, & k = 1,4; \\ \sum_{i=1}^{n} P_i^k, & k = 2,3; \\ \sum_{i=1}^{n} P_i^k \Big/ n, & k = 5. \end{cases} \tag{9}$$

4.3. Simulation-based performance calculation

Since the performance of business reliability (P_s^1), flexibility (P_s^4), and organization relationship (P_s^5) just reveal the performance of the structure of $SOBP_s$, they can be calculated by (7)-(9). However, the performance values of business time (P_s^2) and cost (P_s^3) of each activity are not determinate usually, but random variables with a certain distributions which may be affected by many factors. Here we will use the system simulation method to calculate them.

The model of $SOBP_s$ will be executed by the simulation engine roundly. During simulating, the simulation engine schedules the enterprise's organization, resources, employees, business rules, data etc and accumulates all the parameters predefined. Obviously the $SOBP_s$'s performance of business time (P_s^2) and cost (P_s^3) will be obtained from the accumulated data which comply with (7)-(9).

To some metrics, the larger values indicate the performances are better (the increasing-metrics). On the contrary, the less value means the better performance to the other metrics (the decreasing-metrics). So they have to be transformed to unified values. Equation (10) can be used to the increasing and (11) to the decreasing.

$$U(P_{i,j}^k) = \begin{cases} \dfrac{P_{i,j}^k - \min\limits_{l=1}^{p_i}(P_{i,l}^k)}{\max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k)}, & \max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k) \neq 0; \\ 1, & \max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k) = 0 \end{cases} \tag{10}$$

$$U(P_{i,j}^k) = \begin{cases} \dfrac{\max\limits_{l=1}^{p_i}(P_{i,l}^k) - P_{i,j}^k}{\max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k)}, & \max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k) \neq 0; \\ 1, & \max\limits_{l=1}^{p_i}(P_{i,l}^k) - \min\limits_{l=1}^{p_i}(P_{i,l}^k) = 0 \end{cases} \tag{11}$$

$$U(P_{i,u_i}) = \frac{\sum_{k=1}^{K} w_k U(P_{i,u_i}^k)}{\sum_{k=1}^{K} w_k}, \tag{12}$$

where $1 \le u_i \le U_i$, $1 \le U_i \le p_i$, $1 \le i \le m$.

Obviously, all the performance metrics of *SOBPs* (i.e., P_s^k, $k=1,\ldots,5$) have to be transformed by (10) and (11) firstly, then the comprehensive performance P_s will be calculated by (12) with corresponding weights.

With all of the comprehensive performance of the SOBP schemes in (5) obtained by simulation and calculation, the scheme with the maximum value, denoted by $M=\max\{P_s, s=1,\ldots,N\}$, is the best one according to the assess criterion here.

5. A case study

Fig.4 is a snapshot of CIMFLOW with a SOBP model that describing a typical process that the manufacturer (1) orders parts from its suppliers; (2) produces well-configured products; and (3) tries to meet the customers' needs. The SOBP has some ASVs and each of them has some PSVs respectively, e.g., the ASV named Transport2 has six candidate PSVs which is shown on the right side of Fig.4.

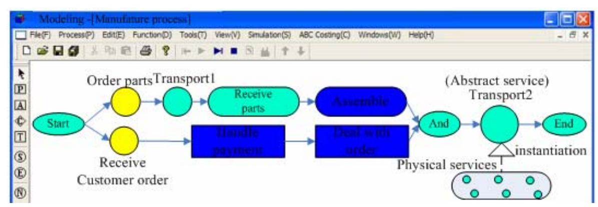

Fig.4. Model of SOBP

5.1. Primary selection of PSVij for each ASVi

Suppose we just concentrate on the five performance metrics (1)(2)(3)(6)(7) of "Transport2", i.e. the metrics set *Pi={ Reli* $_{busi}$, *Time*$_{bus}$, *Cost*$_{busi}$, *Qtime, Qavail}*. Let the fuzzy remark set *V={Good, Medium, Bad}*, and the judge matrix as below:

$$A = \begin{bmatrix} 1 & 1/2 & 1/3 & 2 & 3 \\ 2 & 1 & 1/3 & 5 & 9 \\ 3 & 3 & 1 & 5 & 7 \\ 1/2 & 1/3 & 1/5 & 1 & 5 \\ 1/3 & 1/9 & 1/7 & 1/5 & 1 \end{bmatrix}$$

So we can calculate and verify the performance metrics weight set *W*= (0.1348, 0.2802, 0.4507, 0.0980, 0.0363).

With the comprehensive analysis of the remarks of the six PSVs of the ASV Transport2, we get the end as Tab.1, and we will get each service's fuzzy relation matrix, e.g. the one of service 1 (S1) is as below:

$$A_1 = \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.5 & 0.4 & 0.1 \\ 0.3 & 0.5 & 0.2 \\ 0.1 & 0.5 & 0.4 \\ 0.6 & 0.2 & 0.2 \end{bmatrix}$$

Thus the comprehensive performance of S1 can be calculated, i.e. $B1$ = （0.3878, 0.4341, 0.1781）, that means 38.78% of remarks consider S1 is Good, 43.41％ medium, and 17.81% bad. Similarly we get the others' comprehensive performance as below:

B2=（0.4594, 0.2964, 0.3095）

B3=（0.6280, 0.1745, 0.1975）

B4=（0.7119, 0.1856, 0.2789）

B5=（0.5648, 0.2486, 0.1866）

B6=（0.2488, 0.4524, 0.2988）

Table 1. Service performance remarks (Good, Medium, Bad)

Pi	Business reliability			…	System Availability
Si	G	M	B	…	…
S1	0.6	0.3	0.1	…	…
…	…	…	…	…	…
S6	0.5	0.4	0.1	…	…

Then we can arrange the order of the services as S4>S3>S5>S2>S1>S6. If the required performance must be better than 0.5, service S4, S3, and S5 will be selected as the candidates of "Transport2".

5.2. Performance metrics calculation and simulation

Suppose the ASVs "Order parts" and "Transport1" have selected their PSVs respectively, and "Transport2" will select one from S4, S3, or S5 which means the SOBP will have three schemes, i.e. activities 1-7 compose with S3 (scheme1), S4 (scheme2), or S5 (scheme3) respectively. All activities' organization relation values are listed in Table12, their metrics values are in Table3 where the SOBP schemes' organization relations are calculated by (6), and the simulation outcomes of different schemes are shown in Table4.

Table 2. Organizatiion relation of activities

O_{ij}	O_1	O_2	O_3	O_8	O_9	O_{10}
O_1	1	0.6	0.9	…	0.5	0.4
…	…	…	…	…	…	…
O_{10}	0.4	0.9	0.9	-	-	1

Table 3. Metrics values of activities in Fig 4

Pi / Ai	Busi rely	…	Organization relation S3	S4	S5
Order part①	0.9	…	0.213	0.177	0.142
…	…	…	…	…	…
S5⑩	0.90	…	-	-	0.213

Table 4. Simulation outcomes of SOBP-schemes

Experiment No		1	2	...	10
Process cycle time	S3	6475	6752	...	6722
	S4	6399	6827	...	6595
	S5	6342	6614	...	6379
Resources Utilization	S3	4.369	4.224	...	4.324
	S4	4.361	4.375	...	4.260
	S5	4.536	4.356	...	4.476

Thus, using (7)-(9), we will obtain the SOBP-schemes' business reliabilities, flexibilities, and organization relations. And we can get different SOBP-schemes' business time, cost, and resources utilizations by simulation (see Table5).

Table 5. Performance of different SOBP-schemes

Pi / Schm	Busi rely	…	Resource utilization	Compose perform
+S3	0.689	…	4.34	0.0642
+S4	0.770	…	3.91	0.1089
+S5	0.730	…	4.38	0.1385

Then we obtain the weights set, Wp= (0.1348, 0.0802, 0.2107, 0.2345, 0.2431, 0.0967), of the metrics in Table5 by AHP. Combined with (10)-(12) we obtain the comprehensive performance of different SOBP-schemes,

$(P1, P2, P3)$ = (0.0642, 0.1089, 0.1385),

That means the comprehensive performance order of the schemes is $P3$(S5)>$P2$(S4)>$P1$(S3), i.e. the scheme SOBP3 composed with service S5 has the optimal comprehensive performance under the criteria here.

6. Conclusion and future work

In this paper, we proposed the service-oriented business process modeling and AHP-simulation-based performance evaluation method which is adaptive to modeling and evaluating performance of business process in the loosely coupled service-oriented computing environment.

Based on the three-level performance metrics of the service, we have revealed the relations of performance attributes among business operations, enterprise application systems, and IT infrastructures which can be used to improve the alignment of enterprise' business, IT system, and IT infrastructure. And the extended activity-network-based SOBP model with our method can be used to predict and optimize the performance of collaboration among enterprises in the service oriented computing environment.

We have discussed much about the selection of a physical service from many services. But a service may be required by many others indeed, and this should be a promising issue in the research of modeling and optimizing the collaboration processes among multiple-service consumers and multiple-providers. On the other hand, future efforts can also be dedicated to validating and verifying the metrics of SOBP further.

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