Value-Added Modelling and Analysis in Service Value Brokerage

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Abstract. In our previous work, we have introduced various *Service Value Broker* (SVB) patterns which integrate business modeling, knowledge management and economic analysis. We have identified that value added is a main driving force for adoption and application of SVB by different stakeholders including providers, customers and public administrators. Based on an e-tourism platform, we analyze the sources of value added which could originate in SVB application from the perspective of various stakeholders. We model the situations of value added balancing and tradeoff in the background of long run and short run economical goals. Experiments and simulations are developed for demonstration purpose.

1 Introduction

Software design patterns [1] have been proved, proposed and verified successfully in the modeling processes of multiple technical domains. However for modeling service oriented computing (SOC) applications, design patterns have to be adapted according to value of Quality of Service (QoS) or business contractual aspects. We refer to this as the *Service Value Broker (*SVB*)* pattern [2]. Brokers have already been proposed for cloud service brokerage [3] which we foresee as an important characteristics of the optimization of E-Service Economics [4]. The related definitions are as follows [2]:

- *Service Value Broker* (*SVB*): driven by a value based goal, when a direct service composition cannot meet some required constraints from the service contract [5] or service level agreement(SLA) such as response time, location, license area, available period, currency format. If the introduction of a intermediate service can help to solve these problems and enable a service composition to be qualified, the introduced intermediate service is a *SVB*.
- *Direct Service Value Broker* (*DSVB*): direct *SVB* is a special type of *SVB* resulting from a composition of services. This composition must bring more

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value to the stakeholder who introduces the *DSVB*. By value we mean not only monetary value but also non-monetary such as reputation and brand value, etc.

In this paper, we propose to use *SVB* as the base to integrate three important sides of a service ecosystem: service provider, service customer and public administration [6]. Each of these three sides maintains an independent interest or value system and at the same time relates to others as an element of an global value calculation system. SVB is expected to function as an important source of *value added* for optimizing the whole system under the comprehensive evaluation/measure in terms of increased business value added.

The rest of the paper is organized as follows: Section2 presents background knowledge and the general scenario. Section 3 presents the analysis of the sources of value added brought by introducing SVB. Section 4 presents the scenario of modeling and calculation of value added. This is followed by related work in Section 5 and conclusions with future directions in Section 6.

2 The Background and Scenario

2.1 Demonstration of SVB

We denote the service contract on the source end of an exchange as CS, the contract on the target end of an exchange as CT, the input of SVB/DSVB contract as iSVB and the output of a SVB/DSVB contract as oSVB.

- **Weather forecasting:** weather forecast is a costly and challenging task, however a lot of organizations might need this service with specific precision request.

  Weather forecasting broker: by subcontracting the weather forecasting to a professional service, it actually implement a reuse of resources including professional knowledge, etc. Similarly we can identify numerous application level brokers such as: vender broker, data cleaning broker, etc.

- **Information privacy:** during a transaction, some pieces of information which are not required or are not necessary for a transaction might be required or leaked without notice.

  Information privacy broker: a service which checks and restricts the usages of service information based on a necessary-only policy may play the broker.

There are various situations where SVBs are composed with different cardinalities of “1:1”, “1:n”, “m:n”, and sequences. Figure 1 shows the state diagram of a E-Service in a SVB composition process. A traditional process is embedded as a comparison. During a traditional process, a service is firstly discovered and then it will go through a sequential process of “*matchmaking* $\rightarrow$ *selection* $\rightarrow$ *composition*”. The result is a local solution which does not fully take advantage

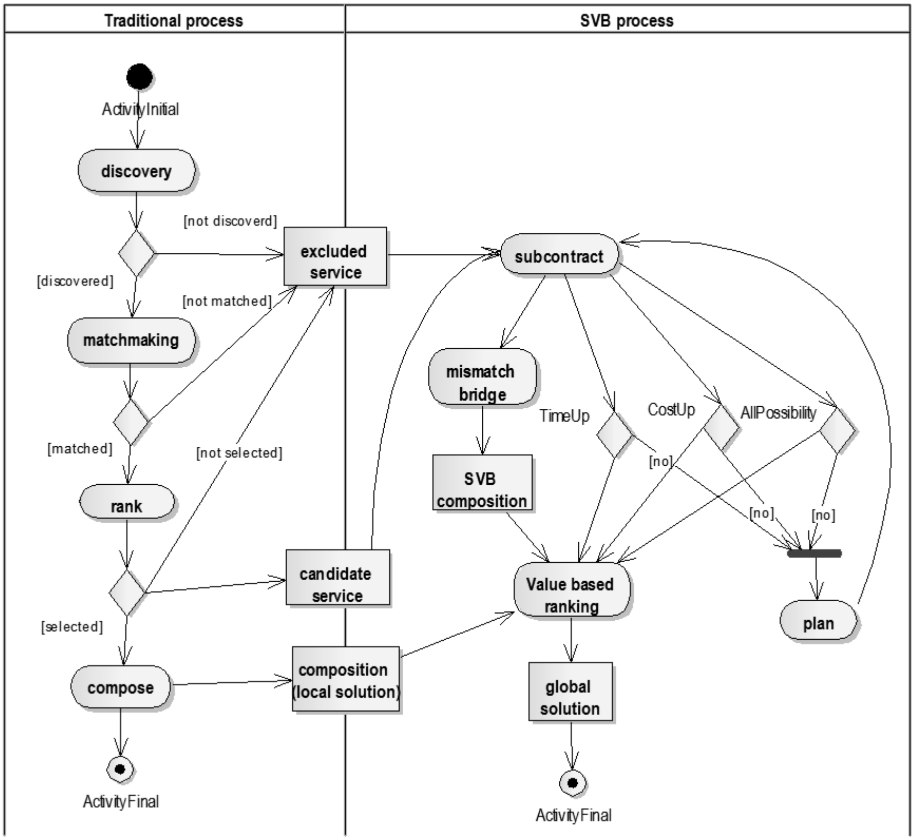

Fig. 1. The object flow

of the potential of the flexibility of E-Services in a scalable cloud environment. When the business value is given the highest priority, the subcontracting relationship implemented by SVB could bring potentially higher value. SVB based solution can fully explore the potential of the available resources, for the processing only when one of the conditions of: (a) the assigned search time is finished, (b) the cost reaches limit, and (c) all possible subcontract scenarios have been explored, has been met, the search will end. The result will be a global best value in terms of business gains on all parties.

2.2 The General Business Scenario

Figure 2 shows the general scenario of multiple service values from mainly three sources. We summarize them as follows:

1. *Provider value (PRV)* - At the service provider side, business value needs to be considered from the temporal dimension as short run vs. long run

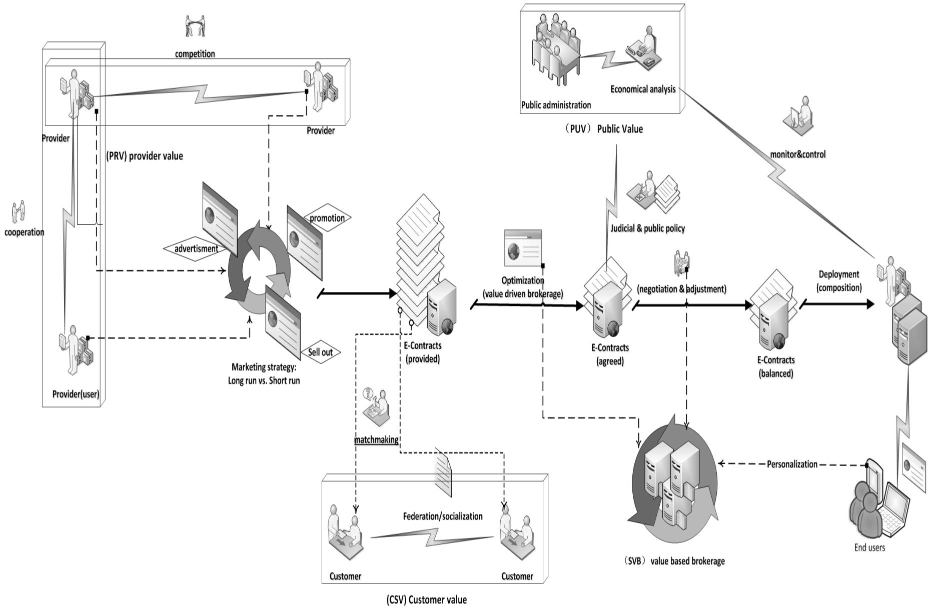

Fig. 2. Integrating value considerations from multiple stakeholder with value brokerage

target which will decide specific business strategies such as new product advertisement, promotion, sell out, etc. Among providers the value can be classified into two categories:

- *Negative competitive cost* - Negative competitive cost occurs when other business competitors who offer similar services bid for the same order or market.
- *Positive cooperative wins* - When service vendors who offer related or similar services agree on some fixed conditions such as market share, sells area, etc, they can build some cooperations to profit from the customer side such as lifting the price of services or charges of maintenance, etc.

2. *Customer value (CSV)* - Service customers in general have independent views on the value of the targeted services. However customers can socialize with other customers to query the quality of a service from others' experiences and comments. The experience information or news/advertisment propagated through social media among customers is playing an increasing role in promoting sales and adjusting commerce behavior. Customers can also build federations to protect their shared interests against malicious service providers with shared cost. Small scale of customer cooperation can cooperate to win promotion sale packages from providers in a win-win manner.
3. *Public value (PUV)* - The public administration is the third party which can play the juridical role for solving the argumentation. The public administration also has other critical responsibilities: (i) monitor the service market through economical analysis to avoid the competition between the provider

and customer side to enter an Zero-Sum game; (ii) employ public policies to intervene the strong cooperation against customer interests at the provider side, or collusive customers [7], etc.

2.3 Domain Knowledge Based Classification of SVB

From the domain of E-Tourism, we have identified many application areas which can be implemented with SVB in different categories[8] which is shown in Figure 3.

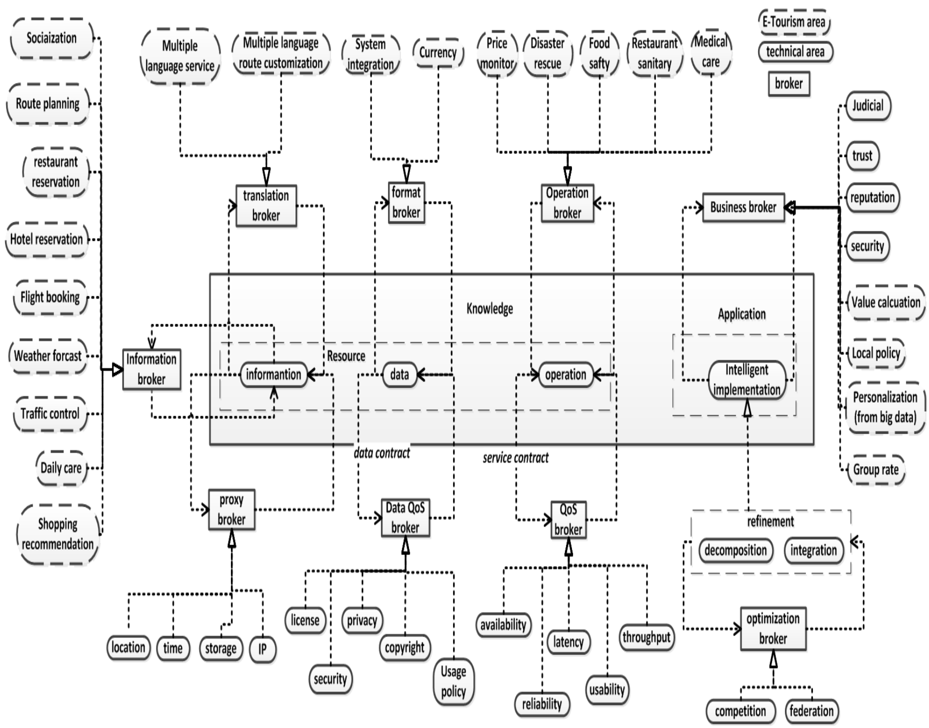

Fig. 3. Empirical SVB classification from a knowledge management perspective

3 The Analysis on *Value Added*

3.1 Sources of Value Added

Building an E-Tourism architecture on top of SVB are expected to have several possible advantages if well managed including the following basic situations:

– *Added value of PRV* - On the provider side, SVB can bring more business chances through relating otherwise not related business together such as creating an international language translation platform which can redistribute translation request to individual translation service providers. The added value $\triangle_{PRV}$ on a specific provider X_P can simplified as as the multiplying of the increased amount of request $\triangle_{req}$ with the difference of the price $\triangle_{price}$. In more detail, we assume the original price, request number and SB (service broker) cost as pri_0, req_0 and SB_0 respectively, and the new price and request number as $pri_0+ \triangle_{pri}$, $req_0+ \triangle_{req}$ and $SB_0+ \triangle_{SB}$ respectively. The added value of provider is formulated as follows:

$$\triangle_{PRV}\ (X_P)$$
$$= (pri_0+ \triangle_{pri} *(req_0+ \triangle_{req}) - pri_0 * req_0 - ((SB_0+ \triangle_{SB}) - SB_0)$$
$$=\triangle_{req} *pri_0 + (\triangle_{req} +req_0)* \triangle_{pri} - \triangle_{SB}$$

The cost on the broker provider X_{PSVB} can be assumed to be balanced to simply the calculation here for demonstration purpose. But in real situation, there can be added value on X_{PSVB} through reuse of information and operation, etc [9].

- *Added value of CSV* - On the customer side, SVB can bring more opportunities through sub-contract [2] relationships for customers to find expected services with the highest comprehensive value. The added value $\triangle_{CSV}$ on a specific customer X_C side can simplified as the sum of the gains from the saved cost on service payment $\triangle_{pay}$, the increased satisfaction $\triangle_{sat}$ and the cost for extra searching $\triangle_{cos}$. In more detail, we assume the original payment, satisfaction and extra search cost as pay_0, sat_0 and cos_0 respectively. We also assume the new price and request number as $pay_0+ \triangle_{pay}$, $sat_0+ \triangle_{sat}$ and $cos_0+ \triangle_{cos}$ respectively. Here we regulate that satisfaction degree sat_0 and $sat_0+ \triangle_{sat}$ ranges between -1.0 and 1.0. Negative value means a negative satisfaction. Positive value means a positive satisfaction. The added value of customer is :

$$\triangle_{CSV}\ (X_C)$$
$$= ((1+sat_0+ \triangle_{sat})*(pay_0+ \triangle_{pay}) - (cos_0+ \triangle_{cos})) - ((1+sat_0)*pay_0 - cos_0)$$
$$=\triangle_{sat} *pay_0 + (1+ \triangle_{sat} +sat_0)* \triangle_{pay} - \triangle_{cos}$$

- *Added value of PUV* - On the public administrative side, SVB can be utilized for several important purposes which include the follows:

  - *Added value of $PUV_{competition}$*- play the judical role which can lower the cost of market adjustment in comparison with the free market situation where Zero-Sum game can hurt the gain of both CSV and PRV. The gains can be calculated as:

    $\triangle_{competition}= \Sigma avoid(loss(PRV)) - cost(interfere(PUV))$.

  - *Added value of $PUV_{cooperation}$*- SVB can also be used to interfere the forming of a dominating side in the provider side through collusive cooperation which will hurt the regular competition and the gain of CSV. The gains can be calculated as:

    $\triangle_{cooperation}= \Sigma avoid(malpractice) - cost(tradeoff(PUV))$.

- *Added value of* $PUV_{security}$- SVB can be employed to provide public qualified third party security services which will save the total spends from the individual cooperations. The gains can be calculated as:
  $\triangle_{security} = \Sigma increaseefficency(individual) - cost(security(PUV))$.
- *Added value of* $PUV_{BigData}$- SVB can be employed by the public administration to evaluate the technological innovations such as Big Data processing for both personalization and public intelligence, and harness their implementation to avoid their malpractice in terms of both business value and social effect. The gains can be calculated as:
  $\triangle_{BigData} = \Sigma avoid(malpractice) - cost(tradeoff(PUV))$.

The general added value brought from public side can be calculated as:

$\triangle_{PUV} = \Sigma \triangle_{competition} + \Sigma \triangle_{cooperation} + \Sigma \triangle_{security} + \Sigma \triangle_{BigData}$.

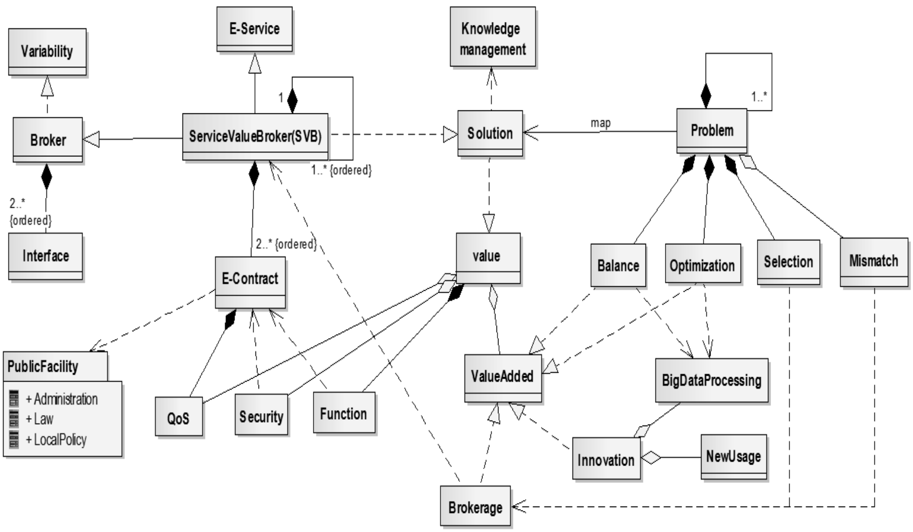

Fig. 4. The metamodel of the brokerage supported value added attaining

The metamodel of SVB is shown in Figure 4. It shows: (a) the inherent architecture of SVB with regard to well known concepts such as interface, broker, E-Service, E-Contract, SLA, and public facility[6] which includes law, local policy and administration; (b) the relationship with target problems including service mismatching processing, service selection, optimization and their composition; (c) the target solution in the form of SVB value including functional value, QoS value, security value and business value in general; (d) the sources of added value related to technological innovation related to Big Data processing, new usage discovery and SVB application. Different from traditional brokers which focus on functional value and QoS, the value which is implemented by SVB requires the composition of business value and functional value.

3.2 Tradeoff on Long Run vs. Short Run

Influence Factors. In classical economics, the profit mode of a business transaction will be distinguished as long run vs. short run [10]. In a long run, factors such as cost and price will be modeled as variables in contrast to being modeled as fixed amount in a short run. This difference will be reflected directly to value added accumulation towards profit-maximization. For a short run mode, the value added of $\triangle_{PRV}$ or $\triangle_{CSV}$ or $\triangle_{PUV}$ will be positive as long as the marginal cost is lower than the marginal revenue which represents the added profit corresponding to the increase of a unit of production. Similarly a production decrease strategy can be made. There are several variability which should be taken as knowledge rules to guide the attaining of the profit-maximization considering both long run and short run.

- *Cost/price adjustment* - by taking advantage of the timely processing of E-Contracts, SVB can realize timely adjusting price to balance the ratio of price/cost for a short run.
- *Marketing plan* - SVB can be composed to implement complex price strategies of a long run such as at the beginning of a business, the marginal cost is allowed to be greater than the marginal price to implement the marketing strategy of advertisement, the price can be increased since after to gain the main profit, and a sold out can be planned to recollect the money flow for an investment with higher reward business, etc. The general evaluation can be positive as long as the average profit in a long run is positive.
- *History based prediction* - the transaction history of customers/providers can be analyzed based on the added value calculation on the top of SVB to make decision on the adaptation of price and production.
- *Public policy implementation* - the public side can employ the power of Big Data processing to analyze added value from various sources covering both $\triangle_{PRV}$ and $\triangle_{CSV}$. Corresponding encouragement policies can be made when the

  $\sum(\triangle_{PRV} + \triangle_{CSV})$

  is decreasing or the acceleration of the increase of the

  $\triangle \sum(\triangle_{PRV} + \triangle_{CSV})/\triangle_{time}$

  is decreasing. Intervention can also be introduced to interfere the situation that the provider side dominates the price making against customer side through the monitoring of the ratio of

  $\sum(\triangle_{PRV})/\sum(\triangle_{CSV})$.

4 Experiment

We implement a prototype system to demonstrate the added value brought by introduction of SVB. We pick the personalization (right lower corner of Figure 2 as an example to show how SVB can improve the value of both the service provider and the customer sides. In the E-tourism, recommending suitable restaurants for tourists will increase the degree of their satisfaction. As a result, it will bring higher profit for both the restaurant and tourism company sides. With a SVB, both parties's attained values are added. Our system offers a value based brokerage service to make personalized restaurant recommendation based on the history rating record provided by previous customers. By delegating recommendation service to value based broker, our experiment shows that such a system could provide added value to both the service provider (tourism company) and the customer (tourist) sides. Specifically, the tourism company (TC) usually delegates the recommendation service to the service broker (SB). It authorizes the SB to access its history records regarding to customers' rating towards restaurants they have visited. TC expects the recommendation service provided by SB to bring added value to both TC and customers. In order to maximize the added value to both customer and TC, SB can sub-contract the recommendation service to multiple *analytic service providers* (ASP_S) in order to evaluation their recommendation service quality and find the best recommendation service. Suppose SB finds that ASP_i offers the best recommendation method, SB will only delegate TC's recommendation service to ASP_i in the future.

Our experiment uses "Restaurant & Consumer Data" dataset[1] from UC Irvine Machine Learning repository to show the above scenario and the effect of SVB in leveraging the added value. We only use the file $rating\_final.csv$, which records 1161 ratings from 138 customers. Each record is a rating of a customer towards a restaurant. The possible rating values are 0, 1, 2. We preprocess the data set and feed the following format to SB: "$customerid \mid restaurantid \mid customer'srating$". We assume that each ASP uses Mahout Recommender[2] as an analytic tool to perform *item based recommender*. However, different ASP uses different similarity measurements. The similarity measurement which each ASP uses is shown in Table 1. The output of the Mahout Recommender is the top ten most recommended restaurants for each customer, along with the predicted rating. In order to test the accuracy of each ASP's recommendations. SB partitions TC's history data into two parts. The first partition consists of 80% of data. The second partition consists of the remaining 20%. For each ASP, SB first feeds it with the first partition so that ASP could learn the rating rule of customers and return the recommendation output. After that, SB will check the accuracy of the recommendation output against the ratings in the second partition. Using the second partition as the ground truth, SB determines the quality of each ASP. It computes the Mean Squared Error (MSE) between the ground truth and each ASP's recommendation output. If the ratings of a specific customer towards a specific restaurant appear in both the ground truth and the ASP output, the square of the rating difference is considered in MSE. Intuitively, a lower value of MSE which a ASP will generate means a higher recommendation quality. Different MSE generated from different ASP is shown in Table 1. (We will explain the Recommendation Accuracy later.) The figure indicates that

[1] `http://archive.ics.uci.edu/ml/index.html`
[2] `https://cwiki.apache.org/confluence/display/MAHOUT/Recommender+Documentation`

Table 1. Mean Squared Errors with different similarity measurements

ASP #	Similarity Measurement	MSE	Recommendation Accuracy
1	Co-occurrence	1.80	0.5
2	Log likelihood	1.80	0.5
3	Tanimoto coefficient	1.81	0.5
4	city block	1.80	0.5
5	cosine	1.79	0.5
6	Pearson correlation	1.45	0.8
7	Euclidean distance	1.80	0.5

ASP #6, which uses Pearson correlation similarity measurement, generates the lowest MSE. When SB finds the best ASP (ASP #6), it will delegate the future recommendation service only to such an ASP.

We model the added value of both the provider (TC) and the customer (tourist) with the employment of *SB*. According to Section 3, the added values of the provider and the customer are as follows:

- *Added value of PRV* - The added value of PRV involves the original price and requests (pri_0 and req_0), added number of customer satisfaction ($\triangle_{req}$), unit price increase ($\triangle_{pri}$),and the recommendation service fee charged by the SB ($\triangle_{SB}$). That is $\triangle_{PRV}$ $(X_P) = \triangle_{req} * pri_0 + (\triangle_{req} + req_0) * \triangle_{pri} - \triangle_{SB}$
- *Added value of CSV* - The added value of CSV involves the original payment and the original degree of satisfaction (pay_0 and sat_0), payment increment for a meal ($\triangle_{pay}$), the degree of increased satisfaction ($\triangle_{sat}$), and the cost of extra search ($\triangle_{cos}$). That is

  $\triangle_{CSV}$ $(X_C) = \triangle_{sat} * pay_0 + (1 + \triangle_{sat} + sat_0) * \triangle_{pay} - \triangle_{cos}$

We assume the unit price of a meal on average is m_0, the recommendation service fee charged by the ASP is r per customer, the delegation fee charged by the service value broker is b. We also assume the total number of customers TC feeds to the SB for the recommendation evaluation is t. The number of customers TC feeds to the SB for the future recommendation is f. We define a recommendation is satisfactory if the customer's actual rating is no less than the recommendation rating by a tolerance threshold, marked as δ. We define the Recommendation Accuracy (RA) as the fraction of satisfactory recommendations in all the recommendations. That is

$$RA = \frac{\#ofsatisfactoryrecommendations}{\#ofrecommendations}$$

In our experiment case, we only consider the recommendation where the customer-restaurant pair appears in the ground truth. For those recommendations, if the rating of a customer towards a restaurant appears in both the ground truth and the ASP output, a recommendation of the ASP is satisfactory only if the ASP's rating is no less than the ground truth rating by δ. The RA is the ratio of satisfactory recommendation to the total recommendations. We set δ as 1.0 in the experiment. We get the RA of each ASP in the last column of

Table 1. Consistent with the MSE, ASP # 6 generates a better recommendation accuracy (0.8), compared to other ASP_S (0.5). We assume that the recommendation accuracy provided by SB is RA. The original recommendation accuracy without using SVB is RA_0. We list all the parameters for the added value model in Table 2. , along with the experiment value we choose. For simplicity, we assume that the meal price increases and the extra search cost as 0. We also assume the original customer satisfactory is 0, the SVB added satisfactory is 1.0, the original recommendation accuracy without using SVB is RA_0. If the customer will make a request only if a recommendation is satisfactory, the number of requests the f future customers will make with and without SVB will be $f * RA$ and $f * RA_0$ respectively. We set RA as 0.8 (according to Table 1), and RA_0 as 0.5, which is equal to the other ASP's recommendation. The number of customers for the training or testing is the number of customers in the recommendation evaluation, which is 138. The number of candidate ASP_S N_{ASP} are 7. The SVB service fee cost includes the broker fee b and the ASP service fee. The service fee charged by ASP is r per customer. At the recommendation evaluation, SB delegates the service to N_{ASP} ASP_S. So the service fee in this phase is $N_{ASP} \star t * r$. Later, SB delegates the service to only one ASP. The cost in this phase is $f * r$.

Table 2. Parameters of added value SVB Model

symbol	**name**	**experiment value**
pri_0, pay_0	original meal unit price	m_0
r	recommendation fee per customer	r
b	recommendation broker fee	b
RA	SVB recommendation accuracy	0.8
RA_0	Original recommendation accuracy	0.5
t	# of customers for training or testing	138
f	# of future customers	f
δ	tolerate threshold	1.0
N_{ASP}	# of candidate ASP	7
$\triangle_{pri}$	meal price increment	0
$\triangle_{req}$	request number increment	$f * (RA - RA_0) = 0.3 * f$
$\triangle_{SB}$	Service fee cost for SVB	$N_{ASP} * t * r + f * r + b =$ $(966 + f) * r + b$
$\triangle_{pay}$	meal price increment	0
$\triangle_{sat}$	satisfactory increment	1
$\triangle_{cos}$	extra search cost	0
sat_0	original satisfactory	0

We compute the added value with the values listed in Table 2. We have $\triangle_{PRV}$ $(X_P) = 0.3 * f * m_0 - (966 + f) * r - b$

$\triangle_{CSV}$ $(X_C) = m_0$

Since $m0 > 0$, the added value for the customer is positive. In order for the added value of provider to be positive, we have $0.3 * f * m_0 - (966 + f) * r - b > 0$

Solving the inequation by f, we have $f > \frac{b+966*r}{0.3*m_0-r}$

To give readers an intuitive understanding, we assume the meal price is \$10, the broker fee is \$1,000, and the recommendation service fee for each customer is \$0.1. We get $f > 378.1$. That is to say, TC will gain added value from the SVB when SB provides restaurant recommendation for more than 378 customers.

5 Related Work

Brokers are envisioned to be a key concern in cloud era, whether in the basic forms of storage brokerage and computation brokerage, or in the advanced form of solution brokerage [11]. Most of existing broker research [12,13,14,15,16,17] focus on using brokers to discover, match, negotiate and select services [18] with best QoS in a service composition. Yu and Li [19] utilize service brokers to meet SLAs in service lifecycle [20]. However, their solution supports only one QoS constraint and a single point of failure. Srikumar et al. [21] adopt brokers to enable grid resource searching and distribution where a broker works mostly as an autonomous agent [22]. D'Mello et al. [23] employ brokers to select qualified services in terms of QoS of SLA for service composition. Loreto et al. [24] use brokers to integrate telephone business and IT world by means of an intermediate layer. Rosenberg and Dustdar [25] use brokers to bridge the difference between heterogeneous business rules. Bichler et al. [26] promote to use brokers to enhance the application level interpretability of electronic commerce. SVB is a value oriented form of "design by unit" [27] which contributes to enable the elasticity of cloud computing. SVB distinguishes from these approach since it starts from the service contract which covers more issues than SLA. SVB is related to services not only on the technological level, as most SLA based approaches [19], but also on the business level [25,28]. By integrating business services and technology services with value modeling, SVB identifies a bigger diagram where it can be successfully applied.

6 Conclusion and Future Work

Service value broker (SVB) is a critical element for constructing a coming era of E-Service Economics since it coherently supports IT implementation of service system and integration of business strategies under the analysis of economical goals. We have empirically collected useful SVBs which can be reused directly by stakeholder in [8]. Value added is a main driven force for adoption and application of SVB by different stakeholder. In this paper, we have analyzed various sources of value added covering service including providers, customers and the public administrative sides. We modeled the value added calculation and analysis based on experimental data to demonstrate the advantage of applying SVB. In the future, we will improve the added value modeling modules on each parties and consider comprehensive business applications in the E-Tourism markets in Hainan province for further refinement and validations.

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