A Fuzzy Model for Service Value Assessment

M. Alessandra Torsello, Leo Iaquinta, and Marco Comerio

University of Milano-Bicocca - Dep. of Informatics, Systems and Communication
Viale Sarca 336, 20126 Milano (Italy)
{torsello, iaquinta, comerio}@disco.unimib.it

Abstract. E-Government (e-Gov) is becoming an important means to produce value for citizens by using innovative technologies in the delivery of more advanced, efficient and personalized services. In this paper, we propose a model for the assessment of the service value defined as the trade-off between benefits and sacrifices perceived by citizens according to their service usage experience. Since human perceptions are subjective and uncertain in nature, the model proposes the use of fuzzy concepts to effectively represent and handle data under uncertain conditions. The suitability of the proposed model is shown by its application on a case study in the e-Gov domain.

Keywords: service value, value assessment, fuzzy evaluation, service evaluation.

1 Introduction

E-Gov creates opportunities to provide added value services to citizens, increasing efficiency and reducing costs. The concept of service value is of interest for researchers and practitioners as it represents one of the aspects that mainly affect user behavior and satisfaction level. In addition, the analysis of service value could provide useful insights for service personalization.

In literature, service value (referred also as *service value in use*) is typically defined as the trade-off between the benefits which users receive by using the service and the sacrifices that they bear in order to get that service [13, 9]. Many works define service value in use as the overall assessment of the utility of a service based on the perception of what is received and what is given [10]. In many studies, a variety of value components that determine benefits and sacrifices for users have been identified. Such components are related to aspects characterizing the service such as its functional properties (FPs), non-functional properties (NFPs) and qualities (Qs). Specifically, FPs concern the functionalities realized by the service, NFPs (e.g., price and payment method) define how the service performs its functionalities, and Qs are aspects characterizing the efficiency and effectiveness of the service. By gathering perceptions of users about such components, it is possible to evaluate the overall benefits and sacrifices for users who use a considered service and thus to assess the value in use of that service. The

assessment of service value may be considered a key element for the provision of personalized services taking into account perceptions and satisfaction level of user groups. Such groups identify user segments including users with similar characteristics which perceive the service in analogous manner. To these segments, organizations may offer more personalized services able to better satisfy the peculiar needs of users.

In this paper, we propose a model for the assessment of the service value in use. The model determines benefits and sacrifices for users by taking into account how a set of service aspects are perceived. The gathered perceptions, being the result of the human thought, have an extremely subjective and uncertain nature. To better capture the uncertainty and the subjectivity that permeate the evaluation process of a service, the model exploits concepts of fuzzy logic. Broadly speaking, the model represents user perceptions in terms of fuzzy sets and it defines a set of fuzzy rules that express the relationship between the actual values of aspects and the benefit/sacrifice as perceived by users. The value in use of the considered service is determined by the fuzzy inference of such rules properly combined with the relevance of each aspect.

The paper is organized as follows. Sec. 2 discusses related works. Sec. 3 describes the proposed model for service value assessment. Sec. 4 reports the results obtained by applying the model to a case study. Finally, Sec. 5 draws conclusions and outlines future works.

2 Related Work

Service value assessment typically involves perceptions expressed by users on service characteristics. In the evaluation processes based on user perceptions, different works propose classical statistical approaches [2, 7]. However, such approaches may result ineffective due to the subjective and uncertain nature of human perceptions. Fuzzy logic is proposed in several research works to handle imprecise knowledge typical in human reasoning. In particular, fuzzy logic has been used for service quality evaluation. For instance, a fuzzy set approach has been proposed in [4] where the customer subjective opinions and the weight of considered factors are described by fuzzy linguistic scales. Each linguistic term is represented by a fuzzy number. The approach considers the importance of each factor and computes the overall fuzzy ratings of all alternatives by using fuzzy number operations. In [3] the authors presented a fuzzy multi-attribute decision-making approach for evaluating dynamically the service quality. Here fuzzy numbers are used to solve the ambiguity of concepts that are associated with human subjective judgments vaguely measured with linguistic terms. In [6] a method based on triangular fuzzy numbers is proposed to measure perceived service quality. The discrepancy between consumer perceptions and expectations is evaluated as the intersection area between two triangular fuzzy numbers.

In previously mentioned works, fuzzy logic has been mainly used to model and process user perceptions in evaluation processes. However, many works exploit fuzzy logic for its ability to build fuzzy inference systems, i.e. models able to

simulate the reasoning of a human expert when he has to take decisions in environments characterized by uncertainty and imprecision. Fuzzy systems are gaining widespread acceptance in service quality assessment. In [8] a hybrid fuzzy expert system is applied to investigate service quality in the academic library. The system is a combination of four fuzzy expert systems: three systems that work in parallel to evaluate three different aspects of libraries and the fourth system which determines the library service quality. In [1] a fuzzy method for evaluating user perception of the security level on social networking sites is presented. Inputs to the system are fuzzy sets representing linguistic variables for information security evaluation. A set of fuzzy rules is built based on the intuitive knowledge of the relationships between the variables.

In this paper, we propose a service value assessment model that exploits fuzzy concepts both to represent user perceptions and to evaluate benefits/sacrifices deriving from the use of the service. Specifically, fuzzy numbers are used to model perceptions. Moreover, a number of fuzzy systems is defined to express relationships among aspects and related benefits/sacrifices. Service value is estimated as the trade-off of benefits and sacrifices determined for all selected aspects by considering their relative importance.

3 The proposed model for service value assessment

To assess the value in use of a generic service s for a set of users U, our model comprises the following steps detailed hereafter:

1. Selection of the service aspects to consider as value components;
2. Gathering of user perceptions about the selected aspects;
3. Evaluation of benefits/sacrifices for each selected aspect;
4. Determination of the weights corresponding to the aspects;
5. Evaluation of the overall benefits and the overall sacrifices for users;
6. Determination of the service value in use.

1. Selection of the service aspects In our model, service value arises from the evaluation of some aspects characterizing the same service related to FPs, NFPs and Qs. Each aspect is a value component and it can represent either benefits or sacrifices for users. For example, the price that a user pays to obtain the service is always considered as a sacrifice that he has to bear and when the price is very low, the sacrifice becomes null. On the contrary, the quality of a service is always considered as a benefit for the user and when the quality is very low, the benefit becomes null. Referring to the service considered in the experimental activity of our model, the following aspects have been selected by distinguishing among benefits/sacrifices and specifying (in brackets) their typology:

- **benefits**: Delivery time (NFP), Transparency (NFP), Fulfillment of user needs (FP), and Overall quality (Q);
- **sacrifices**: Price (NFP), and Request time (NFP).

2. Gathering of user perceptions about the aspects The evaluation of each selected aspect is performed by exploiting the perceptions of users that express judges about their service usage experience. To gather user perceptions, different ways could be employed such as interviews, questionnaires, focus groups, etc. In this work, perceptions are gathered by requiring users to fill a questionnaire that includes questions about each considered aspect. Users express their perception by choosing one of the levels among those included in Likert scales with a odd number of levels labeled by linguistic terms. The choice of adopting scales with linguistic terms is essentially due to the fact that users express their perceptions in more natural way in words rather than by numeric values. In addition, for each aspect related to NFPs, users are required to specify the actual value experimented in their experience as well as a range of values retained acceptable for that aspect. Such values are useful to quantify the benefit/sacrifice determined by the aspect. The considered aspects do not have all the same importance and different users may ascribe them different relevance degrees. In order to determine the aspect importance, the questionnaire includes questions requiring users to sort the aspects according to their relevance.

3. Evaluation of benefits/sacrifices for each aspect User perceptions are processed to quantify benefits/sacrifices related to each considered aspect. User perceptions are subjective and uncertain. To better handle the imprecision and the subjectivity of the gathered perceptions, our model exploits the ability of fuzzy logic to represent and process information under uncertain conditions.

First of all, each linguistic term of the evaluation scales adopted in the questionnaire is represented by a triangular fuzzy number (TFN), i.e. a fuzzy set with a triangular shape. Such kind of representation helps to deal with the imprecision inherent verbal perceptions. Fuzzy numbers, with respect to the use of crisp values, allow to better capture the subjectivity of the judges expressed by users. Moreover, since fuzzy numbers are based on real values, the information contained in them may be better handled, explored and mathematically exploited. According to [12], the semantic of scale linguistic terms is defined by fuzzy numbers as shown in Fig. 1 depicting a scale with 7 linguistic terms, namely N (None), VL (Very Low), L (Low), M (Medium), H (High), VH (Very High) e P (Perfect).

To determine benefits and sacrifices related to each aspect, two different procedures are performed according to the aspect typology: a first procedure concerns aspects related to FPs and Qs, and a second procedure concerns NFPs.

Procedure for FPs and Qs As concerns such kind of aspects, perceptions expressed in terms of fuzzy numbers are aggregated by the fuzzy average operator [5] in order to evaluate the corresponding benefit value represented by a TFN. Finally, this is defuzzified to obtain the corresponding crisp numeric value. Different defuzzification processes could be adopted. This work uses the "center of the area" method [11] that substantially associates to the TFN the abscissa of the geometric center of the area under its membership function.

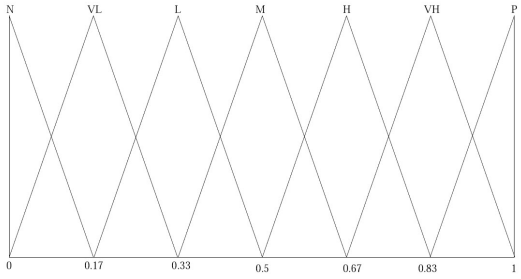


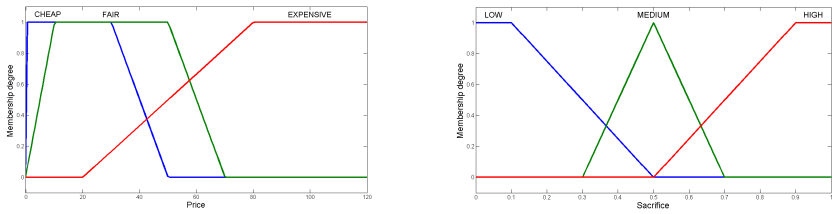
Fig. 1. A scale of 7 terms with its semantics

Procedure for NFPs As concerns NFPs, perceptions of value ranges retained acceptable by users are determined. Such value ranges are processed to derive the benefit or the sacrifice to be associated with actual values assumed by an NFP. To do this, for each aspect, a set of fuzzy rules is defined starting from the gathered data relying on the knowledge of the domain expert. For instance, one rule for the price aspect is defined in the following form:

$$\text{IF } price \text{ is CHEAP THEN } sacrifice \text{ is LOW}$$

To derive such rules, fuzzy sets on input and output variables in the antecedent and the consequent of each rule have to be defined. Fuzzy sets on input variables are defined by analyzing the gathered data. In particular, perception levels in the Likert scales are merged to obtain three fuzzy sets corresponding to positive, neutral and negative perceptions. Neutral perceptions coincide with the middle scale level. Positive and negative perceptions refer respectively to the highest and the lowest scale levels. Membership functions are defined by exploiting the frequency of values on which users have expressed the respective perception level. The membership degree of a value to the respective fuzzy set is proportional to the corresponding frequency. As an example, the three fuzzy sets CHEAP, FAIR, and EXPENSIVE defined for the price input variable of a sample service are depicted in Fig. 2(a). On the output variables (benefit or sacrifice according to the considered aspect), three fuzzy sets are defined, namely LOW, MEDIUM, and HIGH, as shown in Fig. 2(b). Once fuzzy rule set is defined for the considered aspect, the benefit/sacrifice in correspondence of the value taken by that aspect is determined by the inference process of such fuzzy rules [5].

4. Determination of the aspect weights Our model associates a numeric value ranging from 0 to 1 to each aspect representing the relevance degree assigned by users. Weights are determined by considering how each user filling the questionnaire orders the service aspects in terms of the conferred relevance. Precisely, as a first step, based on the specified position, a score is assigned to each aspect. In our model, the score assignment is inspired to competition ranking where each ranked position is associated with a numeric value that reflects the



(a) (b)

Fig. 2. Membership functions for price (a) and sacrifice (b) of a sample service

relationships between a set of competitors according to their final position in the ranked list. Next, aspects are split up into two sets representing benefits and sacrifices and the total score for each set is computed. Successively, the weight of each single aspect is calculated as the ratio between the score assigned in the first step and the total score of the set it is member of. In this way, the sum of benefit weights and the sum of sacrifice weights are separately equal to 1. Finally, the weight of each aspect is estimated as the average of weights of that aspect calculated for all users.

5. Evaluation of the overall benefits and sacrifices Weights and values of benefit/sacrifice for the selected aspects are combined to determine the value of the overall benefits and sacrifices for all users. The overall benefits are calculated by the weighted average of the benefit values related to the aspects that determine some kind of benefit for users, as follows:

$$ob_{s,U} = wb_1 * ben^1_{s,U} + ... + wb_{N_b} * ben^{N_b}_{s,U} \tag{1}$$

where N_b is the number of aspects classified as benefits, wb_i, $i = 1, ..., N_b$, represent the weights for those aspects, $ben^i_{s,U}$, $i = 1, ..., N_b$, are the respective benefit values. Analogously, the overall sacrifices are calculated by the weighted average of the sacrifice values related to the aspects that determine some kind of sacrifice for users, as follows:

$$os_{s,U} = ws_1 * sac^1_{s,U} + ... + ws_{N_s} * sac^{N_s}_{s,U} \tag{2}$$

where N_s is the number of aspects classified as sacrifices, ws_j, $j = 1, ..., N_s$, represent the weights for those aspects, $sac^j_{s,U}$, $i = 1, ..., N_s$, are the respective sacrifice values.

6. Determination of the service value in use In our model the value in use of a service s perceived by a set of users U is computed as the ratio between the overall benefits $ob_{s,U}$ (as in eq. 1) and the overall sacrifices $os_{s,U}$ (as in eq. 2) as follows:

$$v_{s,U} = \frac{ob_{s,U}}{os_{s,U}} \tag{3}$$

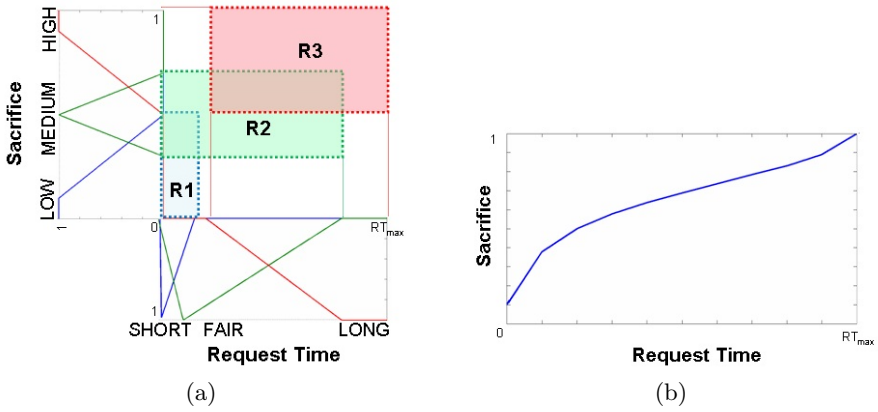


Fig. 3. Rules (a) and sacrifice curve (b) for request time

A value in use equal to 1 is obtained when perceived sacrifices are fully balanced by perceived benefits. A value greater than 1 means that perceived benefits overcome perceived sacrifices. On the contrary, a value in use less than 1 indicates that, for that service, sacrifices are perceived by users as weightier than perceived benefits.

4 A case study

The proposed model for service value assessment was applied on a case study to verify its suitability. In the SMART (Services and Meta-services for smART eGovernment) project, we analyzed services needed for entrepreneurs who want to open public businesses. Among these, in this work, we focus on the results obtained from the value analysis performed on the service of Internet connectivity provision to public businesses being one of the most experienced services.

The first step was consisted in selecting the aspects to consider as value components. For the considered service, the aspects listed in Sec. 3 were selected. The price aspect was distinguished into *activation price* and *monthly price* to indicate respectively the fee paid by the entrepreneurs when the service provision starts and the fee paid each month for the provision. In this way, a total number of 7 aspects were selected, that are *activation price*, *monthly price*, *request time*, *delivery time*, *transparency*, *fulfillment of user needs*, and *overall quality*.

In the second step of our model, user perceptions were gathered by questionnaires investigating the usage experience of about 10 services useful to open public businesses in Italy such as café and Bed & Breakfast. At the end of this step, a total number of 102 questionnaires filled by entrepreneurs were collected. However, each entrepreneur was asked to answer questions about at most three experienced services. Thus, for the Internet connectivity service considered in the case study, perceptions expressed by about 20 entrepreneurs on the aspects previously selected were gathered.

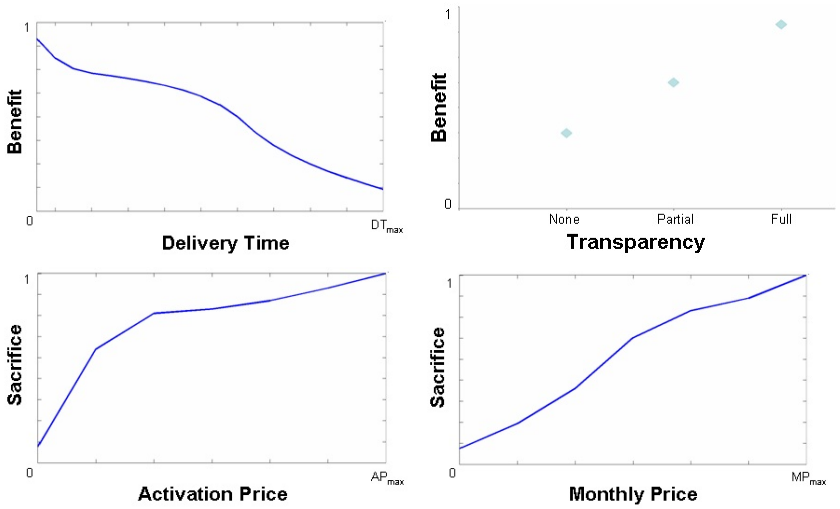


Fig. 4. Benefits/sacrifices for delivery time, transparency, activation/monthly prices

In the third step, benefits and sacrifices related to each aspect were obtained by applying the appropriate procedure as described in Sec. 3. Precisely, as concerns NFPs, for each aspect a set of fuzzy rules was defined starting from the gathered perceptions. As an example, the fuzzy rule set derived for the *request time* aspect is shown in Fig. 3(a). As it can be seen, three rules have allowed to cover the gathered perceptions and to establish the relationships among *request time* and *sacrifice* values. The derived relationships are synthesized in the following rules:

R1: IF *request time* is SHORT THEN $sacrifice$ is LOW
R2: IF *request time* is FAIR THEN $sacrifice$ is MEDIUM
R3: IF *request time* is LONG THEN $sacrifice$ is HIGH

Fig. 3(b) shows the sacrifice curve obtained by the inference of rules for all possible request time values. In Fig. 4, we show the trend of benefits and sacrifices obtained for the other considered aspects related to NFPs. Particularly, the transparency values are not in a continuous range (like for the other considered NFPs), but 3 different levels were considered, namely *None*, *Partial*, and *Full*, corresponding to the different degrees with which entrepreneurs receive information about the provision progress of the requested service.

As concerns FPs and Qs, perceptions expressed in terms of TFNs were aggregated by the fuzzy average operator. The TFNs obtained as a result were $\tilde{F} = (0.47, 0.64, 0.80)$ and $\tilde{Q} = (0.42, 0.67, 0.91)$ for fulfillment of user needs and overall quality, respectively. Such TFNs were defuzzified into crisp values obtaining 0.64 and 0.67, respectively.

In the next model step, weights of all the aspects were calculated as explained in Sec. 3 and the obtained values are reported in the third column of Table 1. To

Table 1. An example of value in use assessment for a sample service

Aspect	**Contract term**	**Weight**	**Benefit**	**Sacrifice**	**Value in use**
Activation price	98 €	0.20		0.81	
Monthly price	45 €	0.60		0.83	
Request time	1 day	0.20		0.38	
Delivery time	7 days	0.46	0.63		
Transparency	Partial	0.18	0.30		
Fulfillment of user needs		0.18	0.64		
Overall quality		0.18	0.67		
Overall			**0.58**	**0.74**	**0.78**

apply the last two steps of the model, we need to consider the values included in the contract of a specific service. Thus, by considering a service for Internet connectivity provision characterized by the contract terms reported in the second column of Table 1, benefits and sacrifices of each aspect can be computed by exploiting the curves derived for NFPs and defuzzified values derived for FPs and Qs. Such values are reported in the same Table 1. By computing the weighted average of benefits and sacrifices previously obtained, the overall benefits and sacrifices were determined having respectively 0.58 and 0.74.

As a final step, the value in use of the considered service was derived as the ratio of overall benefits and sacrifices obtaining a value equal to 0.78.

The performed value analysis points out that entrepreneurs perceive the monthly price as the most relevant aspect (weight 0.60) and the related perceived sacrifice is also the highest (0.83). On the other hand, the second most important aspect (weight 0.46) is the delivery time for which entrepreneurs perceive a quite high benefit (0.63). In correspondence of all the other aspects, entrepreneurs associate a low relevance degree (weight 0.18 or 0.20) and, consequently, these components weakly affect the assessed value. Thus the most important sacrifice perceived for the monthly price is mainly alleviated by the benefit perceived for the delivery time. As a consequence, the resulting final value in use (0.78) is quite near to 1 (that corresponds to the situation in which benefits balance sacrifices) despite the most relevant sacrifice referred to the monthly price. Such kind of analysis can be useful whenever a user has to choose among different available services. In fact, in such situations, indicators about perceived benefits and sacrifices may provide helpful cues to support users in selecting the most valuable and personalized service.

5 Conclusions

In this paper a model for assessing the service value in use has been proposed. An accurate analysis of service value may offer useful hints to provide personalized services able to meet the peculiar needs of users. Service value is quantified as the trade-off of benefits and sacrifices perceived by users when using the service. To better model the subjectivity inherent any perception-based evaluation process,

the model benefits from the ability of fuzzy logic to handle information under uncertain conditions. Results obtained by the experimental activity carried out on a service of the e-Gov domain encourage the application of the model on other services and perceptions of a wider number of users to definitely assess the effectiveness of the model. As future work, starting from a larger collection of user perceptions, the automatic derivation of membership functions and rules could be an interesting point to address together with the possibility to automatically refine the rules by a proper learning process.

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