



Service Science

Publication details, including instructions for authors and subscription information:
<http://pubsonline.informs.org>

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To cite this article:

Marek Winkler, Vladimír Dosoudil, (2011) On Formalization of the Concept of Value Proposition. Service Science 3(3):194-205. <https://doi.org/10.1287/serv.3.3.194>

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On Formalization of the Concept of Value Proposition

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This paper presents an original description and a semi-formal definition of the concept of a value proposition, which has been so far used in service science rather intuitively. Our approach is based on utility functions and conceptual modelling techniques. The proposed semi-formalization can be exploited to describe services from the point of view of their (potential) utility for their clients. This description can be used especially to organize a service portfolio in an enterprise in a better way, aid in computer-assisted service composition/decomposition, and provide additional criteria for indexing services in a service brokering task. In order to be able to describe a value proposition more accurately, we present a semi-formal definition of the concept of a service system. We perceive a value proposition as the main input taken into account by a future service client when evaluating whether or not to become the client of the service proposed by a service provider. A value proposition itself is modelled as a collection of values which indicate the extent of “how much” a given service behaves according to a given set of service characteristics. The presented approach is illustrated on the example of a concrete service.

Key words: value proposition; utility function; service modelling; service science

History: Received Sept. 24, 2010; Received in revised form Mar. 29, 2011; Accepted Apr. 4, 2011; Online first publication Jun. 6, 2011

1. Introduction

The importance of services and their systematic study is nowadays well recognized in the multidisciplinary research field called *service science* (Alter 2008, Spohrer *et al.* 2007). The perspective of service science has already impacted thinking about services in *computer science* as well (Harry 2009, Qiu 2009). This paper aims to become another contribution to the computational thinking about services, however, focusing on so far untouched aspect of computational modelling of services, the value proposition.

What do we understand by a value proposition? This term was introduced by Michael Lanning (1998):

“The combination of resulting experiences, including price, which an organization delivers to a group of intended customers in some time frame, in return for those customers buying/using and otherwise doing what the organization wants rather than taking some competing alternative.”

However, the original meaning of value proposition has shifted, and nowadays the value proposition often refers to *the attributes of offered service/goods* instead of *delivered experiences*. Both interpretations are manifested in terms of a *value proposition* and an *acceptable value proposition* defined later in this paper.

Is such a topic worth the effort? According to Qiu (2007), *the value of delivered service lies in its ability to satisfy customer’s need, which is not simply and strictly shown in the technical characteristics of the service (and the physical attributes of the products included in the service)*. We believe that our proposed approach can help better describe and understand customer’s needs, map those needs onto existing services in order to support their innovation, and improve design of new services.

As we have already indicated, this paper investigates the important aspect of a service – the value proposition. After a brief discussion of related work, we recall the basic concepts of service science, i.e. a *service system* and a *service*. We also introduce a *formal service system* that describes the aspects of a service system, which are important for our understanding of the value proposition, more technically. Next section of this paper presents the *utility function* known from economics. Later in this article we describe a possible approach to modelling service

characteristics for the utility function. Drawing from the previously introduced concepts, we define a *value proposition* and an *acceptable value proposition*, and illustrate the proposed approach on a car rental service. Finally, we mention possible application of our approach in *indexing services* and conclude with our planned future work.

2. Related Work

We build our perception of *service* and *service system* on the work of Vargo and Lusch (2004), Maglio and Spohrer (2008), and Maglio *et al.* (2006). We needed more technical definitions of these two concepts, and therefore we have developed more formal definitions focused on those aspects that are important for the purpose of this paper. The definitions are described in section 3 of this paper.

As this paper is targeted at semi-formalization of the important part of service systems, the value proposition, we looked for any published works on formalizing services or service systems. We have found the computational view of service systems by Qiu (2009), concentrating on dynamics and adaptiveness aspects. Qiu follows the process-driven *business process management* (BPM) approach and formalizes a service system using an automaton-based structured workflow language and π -calculus.

We do not attempt to develop another formal description of operations, i.e. processes or *services*, running in a service system; we try to describe the qualities of these services and propose a semi-formal method of mapping these service qualities onto client's needs. Such mapping can be used to identify what service qualities are demanded, while the semi-formal description of service qualities can be used to improve service provider's knowledge of available services. A semi-formal description is usually comprehensible quite easily for a businessperson or a domain expert while providing pragmatically chosen level of structure organizing the contents of the description. This semi-formal level combines perfectly with Qiu's approach, which offers formal description suitable for the design and implementation of business processes which implement the identified services. The relationship between the proposed semi-formal method and Qiu's approach resembles the relationship between conceptual and logical data models.

In the field of marketing there are resources (such as (Barnes *et al.* 2009)) that offer a comprehensive guide on creating and delivering value propositions. Osterwalder and Pigneur (2003) present an elaborated conceptual approach to modelling value propositions. They describe comprehensibly the motivation for capturing the value proposition by means of rigorous modelling.

Other fields, such as medical services, have to deal with value propositions as well. The need to focus on measuring service quality by other means than only economical is indicated in (Feazel and Murren 2003), and later a framework to manage the early value proposition in healthcare technologies is presented in (Davey *et al.* 2010).

Our position in this paper is more computationally oriented. The aforementioned approaches provide a broader context for our modelling approach whereas we focus on modelling the value proposition itself to provide tools for reasoning about this subject by means of computer science. We are not aware of any previous attempt to provide a semi-formal definition of the value proposition in a similar manner.

3. Service Systems

Because this paper's main objective is to semi-formally define the value proposition of a *service*, we have to clarify what we understand by the term *service* (and the closely related term *service system*). Let us first recall relevant definitions as they are defined in service science:

A *service* is understood as "*the application of competences for the benefit of others*" (Vargo and Lusch 2004). In general, a service is delivered by the service provider to the service client. In fact, the service can act on a target different from the service client, but the service does so for the benefit of the client. This general definition has been extended by describing the parts involved (service client, service provider and service target) and their mutual relationships and actions in the process of service provision in (Maglio *et al.* 2006).

Service systems are "dynamic value co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures and methods)." (Maglio and Spohrer 2008)

An extended form of the previous definition focusing on contexts and time-aspects of service systems has been proposed by Staníček (the full version of the definition can be found in (Staníček and Winkler 2010)):

A service system “is a composite of agents, technology, environment, and/or organization units of agents and/or technology, functioning in space-time and cyberspace for a given period of time. There is always a lot of contexts from which the service system could be evaluated, explicated and comprehended. There exists at least one context from which the roles of Client, of Provider, and of Target could be recognized on agents or environment.”

In order to avoid ambiguity in the later presentation of the semi-formal definition of the value proposition, we are going to transform the aforementioned definitions into a more technical notation. Because we concentrate on the aspects of service systems which are important for our definition of the value proposition, we do not attempt to provide a complex technical definition of a service system. Instead, we define the notion of a *formal service system* (FSS), which particularly leaves out the aspect of service system evolution in time. We can imagine FSS as a snapshot of a service system taken at a particular time instant. The exact extent of FSS limitations, in comparison with general service systems, and possible means of enhancing the FSS definition are subject to further investigation.

First of all, we are going to explain how we model the parts involved in a service. When we refer to *service client*, *provider* or *target* in the following definitions, let us assume they are modelled as sets (in mathematical sense) of their parts involved in a service. The reason for this decision lies in the need to be able to describe decomposition of these parts (remember that, for instance, a service provider may be an individual as well as a whole organization). The mathematical concept of a *set* provides the simplest, yet sufficient for the purpose of this paper, means of modelling decomposition. Indeed, a mere set is sufficient in this case because we do not need to model how the parts (e.g. agents involved in the provider organisation) form the whole (e.g. the provider organisation).

Before we start with the definition of a *formal service system* (FSS) let us define the following three relationship categories used in the definition:

- An object from the category *client-vp* is any relationship with the following meaning: *Client parts* that participate in a service described by a given *value proposition*.
- An object from the category *provider-vp* is any relationship with the following meaning: *Provider parts* that participate in a service described by a given *value proposition*.
- An object from the category *target-vp* is any relationship with the following meaning: *Target parts* that participate in a service described by a given *value proposition*.

Definition 1 (formal service system) Let C be a service client, P a service provider and T a service target. Let VP be a set of value propositions¹ and CAT be a set of relationship categories containing at least categories *client-vp*, *provider-vp*, *target-vp*. Let $SS = (V, E)$ be any directed graph, where V is the set of vertices and E is the set of edges. If the following conditions hold, we say that SS is a formal service system:

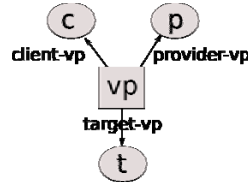
1. V is the set of vertices representing service system elements (i.e. people, technology, shared information, value propositions, ...); $V = C \cup P \cup T \cup VP$
2. $E \subseteq V \times V \times CAT$ is the set of edges such that, for any $v_i, v_j \in V$, $cat \in CAT$: $(v_i, v_j, cat) \in E \Leftrightarrow$ the service system element v_i is related to the element v_j by a relationship from the category cat ,
3. SS contains at least one subgraph $S = (V', E')$ (service subgraph) such that:
 - (a) $V' = \{c, p, t, vp\}$, where $c \in C, p \in P, t \in T, vp \in VP$,
 $E' = \{ (c, vp, client - vp),$
 $(p, vp, provider - vp),$
 $(t, vp, target - vp)$
 $\}$
 - (b)

¹ Technically, $VP \subseteq P(Q_1 \times \dots \times Q_k)$, where $k \in \mathbb{N}$, $P(X)$ denotes the power set of the set X , and Q_i is the set of values of an objective characteristic i . The definition of the value proposition is explained further in section 6 of this paper.

A few words about the set (*CAT*) of relationship categories. The service system elements can be connected by various relationships. We do not know, in advance, all the possible relationships that might be useful to incorporate into the model. For this reason, the definition does not restrict the possible categories of relationships between the model elements. The only requirement on the set *CAT* is that it must include at least the three relationship categories *client-vp*, *provider-vp*, and *target-vp*, because the modelled system needs to be able to establish relationships constituting at least one *service* to be called a *service system*.

Figure 1 illustrates the connections between individual vertices in the service subgraph from the previous definition. Now, we are ready to define a *service* as the collection of processes taking place among the components of the service subgraph.

Figure 1 Service Subgraph Illustration



Definition 2 (service) Let $SS = (V, E)$ be a formal service system (FSS) and $S = (V', E')$ be a service subgraph of SS according to the definition of a FSS. By service we understand the collection of all processes aimed at fulfilling the value proposition in S and taking place among elements represented by vertices from S .

The service subgraph S is uniquely identified by its vertices, therefore we will use alternative, more compact, notation (c, p, t, vp) to denote S . We will also use the term *service* S as the abbreviation of the term *service identified by the service subgraph* S .

4. Utility Function

We build our approach on the concept of a *utility function* already known from economics. We have chosen this method because it combines very naturally with the value proposition definition proposed later in this paper. However, once a value proposition is formulated, other measures for evaluating if a service meets its value proposition can still be used.

The utility function is able to compute the amount of utility of a specific entity for some other entity. In this paper, we apply this general concept in services, and for that reason we use the utility function as a “device” which yields the amount of utility of a given service for a particular service client.

Definition 3 (utility function) Let us consider a service $S = (c, p, t, vp)$. We denote U_S^k to be the k -dimensional utility function of the service S for its client:

$$U_S^k = Q_1 \times \dots \times Q_k \rightarrow \mathbb{R}, \text{ where}$$

Q_j is the set of values of the j -th objective characteristic relevant for the service S , $j \in \mathbb{N}, 1 \leq j \leq k$,

k is the number of objective characteristics relevant for the client c .

We use the term the utility function of the service S , denoted by U_S , for a k -dimensional utility function of the service S for some $k \in \mathbb{N}$.

The utility function computes the amount of utility of the service S for the client c according to a given collection of service characteristics. These characteristics can be different for various services and should be defined carefully in co-operation of both the service provider and the client, for example, by means of an appropriate set of conceptual and other models. This may involve a single reference conceptual model providing an overarching

abstract view of individual services as well as more specific data or process models necessary to define more specific characteristics required for particular services.

Examples of objective characteristics of a service include both quantitative properties (performance, reliability, etc.) and qualitative properties (i.e. what the service actually does). We will explain the characteristics and their values in the following section.

The last concept necessary to define the value proposition is the *domain* $D(U_S^k)$ of the utility function U_S^k of a service S . We understand the *domain of a function* f as the set of all values x such that $f(x)$ is defined.

Let us now discuss what exactly the service objective characteristics look like, how to model them, and capture their semantics.

5. Modelling Objective Characteristics of a Service

The utility function computes the utility of a service according to the collection of service characteristics and their values. We have already indicated what a value of each characteristic may look like; but how to describe the characteristics themselves?

We do not propose using a strictly formal modelling approach. Instead, we suggest working with a reasonable enough (i.e. semi-formal) definition of each characteristic. However, we do not “forbid” defining service characteristics formally; we merely allow to use semi-formal approach in cases where providing formal definitions would be extremely demanding or even impossible.

Our proposed modelling approach resembles (and in fact originates from) the conceptual modelling method called HIT (Duží *et al.* 1986). The conceptual modelling can be described as *the process of conceptual understanding and rendering modelled part of reality. The modeller tries to find out which objects of interest the system should keep and provide. Conceptual model should be totally independent of intended implementation and intelligible for users* (Duží 2002).

In other words, the conceptual model describes the concepts and their relationships identified in the modelled domain. A good conceptual modelling technique should make the analyst reduce the amount of the resulting model ambiguity as much as possible. For this reason, we have chosen the conceptual modelling method HIT, which is focused on well-formed (semi-formal) definitions of all the concepts and the relationships in the model.

In HIT, the modeller is focused on semantics of all elements of the model. Therefore, the Entity-Relationship diagram of the model is only a secondary result of the modelling process and can be derived from the textual part of the model. The strong orientation on semantics results in the *functional* orientation of HIT (on the contrary to the *relational* modelling constructs commonly used in modelling). A *function* can be defined as a special case of a *relation*. The reason why HIT perceives all model elements as functions is partly the fact that a semantic definition of a model element can be formulated in a structured way, but still using a natural language, rather as a function than a relation.

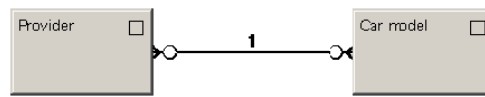
Our intention in this section is to propose a method of describing the characteristics of the modelled service, inspired by the conceptual modelling method HIT.

Quantitative characteristics express measurable properties of the considered service or its part. The measurable properties may describe the service provision itself, such as reliability or performance, or the domain of the service, such as the rental rate or the maximum speed of a car available for rent. The characteristics values are real numbers.

Qualitative characteristics express service attributes which cannot be simply measured using a number scale. The characteristics of this kind usually express that some fact about the considered service is true or false. (Later in this section we introduce *conditions of satisfaction of a characteristic* enabling to further refine the characteristics.) Taking a car rental service as an example, its basic qualitative characteristic would be that this service offers cars for rent to its clients. We can model this situation by using the following simple conceptual model (see Figure 2 for the diagram of the model):

- An object of category (**#Provider**) is any agent (person or company) acting as a service provider.
- An object of category (**#Car model**) is any particular design or version of a car.
- Relationship 1: (**#Car model**)-s offered for rent by a given (**#Provider**). / 0,M:0,M

Figure 2 Car Rental Service — a provider offers cars (of particular car models) for rent (model diagram).



According to the HIT conceptual modelling method, the Relationship 1 is understood as a *function* taking an entity from the sort (**#Provider**) as the input, and returning those entities from the sort (**#Car model**), which are offered for rent by the input argument (provider entity). The expression $p,q:r,s$ defines the cardinality of the relationship as follows:

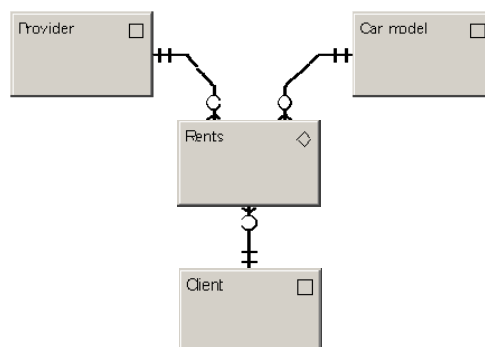
- the $p \in \{0,1\}$ determines if the function is partial or total (in the case of the relationship 1, there can be a provider that offers no car model for rent),
- the $p \in \{1,M\}$ says if the function returns at most one or more results (in the case of the relationship 1, there can be a provider that offers more than one car model for rent),
- the pair r,s is the analogy of the p,q for the “rotated”² function, in the case of the relationship 1 the rotated function is (**#Provider**)-s offering for rent a given (**#Car model**). The cardinality $0,M$ says that zero or more providers that offer for rent a given car model can be returned by the function.

More detailed and rigorous definitions of the HIT method concepts are beyond the scope of this paper and can be found in (Duži 2002) or (Duži *et al.* 1986).

Another qualitative characteristic of car rental service might express that the service provider rents a car (of a particular model) to the client. Let us have a look at the model (see Figure 3 for the diagram):

- An object of category (**#Provider**) is any agent (person or company) acting as a service provider.
- An object of category (**#Client**) is any person holding a valid driving license interested in the service.
- An object of category (**#Car model**) is any particular design or version of a car.
- An object of category (**#Rents**) is any representation of relationship among a provider, a client and a car model, with the following meaning:
(**#Client**)-s who have rented a car of a given (**#Car model**) from a given (**#Provider**). / $0,M:0,M$

Figure 3 Car Rental Service – a client rents a car from the provider (model diagram). The rectangles with boxes represent primary entities, while the rectangle with the diamond ((#Rents)) denotes an entity representing a relationship.



As we have illustrated, qualitative characteristics can be captured by means of appropriate models, e.g. conceptual, process or other models. Elementary characteristics may be pragmatically combined to form complex characteristics by joining their models. Such a combination may be useful for reducing the number of arguments of a

² The definition can be found as the term *HIT attribute rotation* in (Duži *et al.* 1986).

utility function. Modelling of characteristics and their combinations deserves further study, however, for the purpose of a utility function, we are interested only in whether or not a particular service behaves according to a particular characteristic.

Therefore, our approach defines the set of values of qualitative characteristic Q_i as the *image*³ of the function E_i which evaluates the value(s) of the characteristic i for a service S :

$$E_i(S) = \begin{cases} 1 & \text{if service } S \text{ acts according to the characteristics } i, \\ 0 & \text{otherwise.} \end{cases}$$

This definition works fine for the characteristics that can be formulated only by means of a model. Nevertheless, there are characteristics which should include some statements about the *population* of the model. For instance, in the case of a car rental service, *car models which are available for rent*, or *locations where the rented car can be dropped off*. The set of values of such characteristics is not a subset of $\{0,1\}$ because the client might be interested in which car models are actually available or what the drop-off locations are. To state simply that *there are some car models available* and *there are some drop-off locations*, as the function E_i does, is not sufficient in this case.

As a result, we extend the function E_i to produce the required information about the model population as well:

$$E_i^*(S) = (E_i(S), C) \quad \text{where}$$

C is the logical formula defining the *condition of satisfaction of the characteristic* i . This is the condition on the population of the model of the characteristic i which is guaranteed to be true if $E_i(S)=1$, i.e. the service behaves according to the characteristic i . If $E_i(S)=0$, the set C is irrelevant and may be ignored. If the characteristic i does not need to be specified on the model population level, the set C will be empty.

Consider again our example – the car rental service S and its two characteristics $i = \text{car models which are available for rent}$ and $j = \text{locations where the rented car can be dropped off}$. The values of $E_i^*(S)$ can be the following:

$$\begin{aligned} E_i^*(S) &= (1, ((\# \text{Car model}) = \{\text{Ford Fusion, Chevy Uplander}\})) \\ E_j^*(S) &= (1, ((\# \text{Location}) = \{\text{Hartsfield-Jackson Atlanta Airport (ATL)}\})) \end{aligned}$$

To conclude, we define the set of values of the qualitative characteristic Q_i as the *image* of the function E_i^* . A value of a qualitative characteristic is represented as a pair (x,C) , where x is a real number and C is a logical formula expressing model population constraints.

In order to achieve a uniform representation of the values of the both kinds of characteristics, we consider the values of quantitative characteristics to be ordered pairs whose first component is a real number and whose second component is the empty set.

Now we are ready to define the value proposition in terms of the aforementioned formalism. Later on, we will also define a value proposition acceptable for the service client.

6. Value Proposition

We mentioned that a utility function returns the amount of utility of the given service for the specific service client. The service can be (not necessarily completely) described by a set of objective characteristics and their values – the sets Q_j that we defined as inputs for the corresponding utility function. We claim that a collection of the values of such characteristics (which are used for evaluation of the utility of the service) represents a value proposition.

Using previously introduced notions, we can define a general value proposition as follows:

³ The *image* of the function f is the set of all outputs obtained when the function f is evaluated at each element of the domain of f .

Definition 4 (value proposition) Consider a service S . Let $D(U_S)$ be the domain of the utility function of the service S for its client. Then any $VP_S \subseteq D(U_S)$ is a value proposition of S for its client.

Please consider the following two special cases of VP_S . Both are quite impractical but they can give you further insight into the proposed formalism:

- the case $VP_S = D(U_S)$ means that VP proposes *anything* in the domain defined by the characteristics that U_S is applied to,
- the case $VP_S = \emptyset$ represents VP which proposes *nothing*.

Although we have defined the value proposition, this definition is very general because, in fact, it allows for any value proposition, even those that no client would accept. We amend this situation by defining the concept of *acceptable value proposition* in the next section of this paper.

According to the presented definition, a value proposition is a set of k-tuples of real number-logical formula pairs. The semantics of each k-tuple element (i.e. the semantics of the characteristic whose value is this k-tuple element) has to be clearly defined in co-operation with both the service client and the service provider. One possible approach is to define a conceptual model over the domain of the considered service (discussed in section 5).

Each k-tuple in the value proposition set is to be interpreted as an *alternative* option proposed by the value proposition. Therefore, it is possible to express a value proposition containing alternatives or intervals in some of its objective characteristics.⁴

7. Acceptable Value Proposition

As we have mentioned earlier, the notion of a general value proposition is not strong enough to distinguish value propositions *acceptable* for a client. This approach is closer to Lanning's original perception of a value proposition (Lanning 1998). We define *acceptable value propositions* in accordance with the intuition: the client uses their utility function to determine utility of the given value proposition. If the result is in some sort of *acceptance interval*, the client usually accepts the value proposition. We can imagine the acceptance interval as some expression of the amount of tolerance of the client for the *utility* of the service.

First, we define the acceptance interval for a particular service client. The following definition does not say how to construct an acceptance interval. Let us assume for now that the interval is derived empirically. It is sufficient for the purpose of this section.

Definition 5 (acceptance interval) Consider a service system SS . Let c be the client of a specific service S in SS . We say that interval $I_c = (a, b)$; $a, b \in \mathcal{R}$ is the acceptance interval for evaluation of the utility of the service S for the client c , iff for any value proposition VP_S holds

$$\text{client } c \text{ accepts } VP_S \Rightarrow \exists \bar{x} \in VP_S : U_S^k(\bar{x}) \in I_c.$$

To provide some examples, an exacting client can be represented by the interval (95,100) whereas a very tolerant client by (30,100). The definition claims that all value propositions of S that would be accepted by the client must contain at least one value proposition element whose utility falls into the acceptance interval.

Now we are able to define an *acceptable value proposition of a particular service for a particular client*:

Definition 6 (acceptable value proposition) Consider a service system SS . Let c be the client of the service S in SS , let interval $I_c = (a, b)$; $a, b \in \mathcal{R}$ be the acceptance interval for evaluation of value proposition utility for the client c , and let VP_S be the value proposition of the service S . We say that VP_S is an acceptable value proposition of the service S for the client c (denoted aVP_S), iff

$$\exists \bar{x} \in VP_S : U_S^k(\bar{x}) \in I_c.$$

⁴ This is similar to thinking of a value proposition as of a logic formula in *disjunctive normal form*.

This definition conforms well with the intuition: to evaluate whether a specific value proposition of the service is acceptable for the client, we need to determine the following two factors:

- how the client evaluates the utility of the proposed service (i.e. the utility function U_S^k for the client),
- which of these evaluations would be “good enough” for the client to accept the value proposition (i.e. the acceptance interval I_c for the client).

Corollary 7 From the last two definitions the following is true:

$$\forall \bar{x} \in VP_S : U_S^k(\bar{x}) \notin I_c \Rightarrow \text{the client } c \text{ does not accept } VP_S.$$

8. Car Rental Service Example

We are going to illustrate the proposed method of value proposition formalization on the example of a car rental service.

8.1 Dictionary

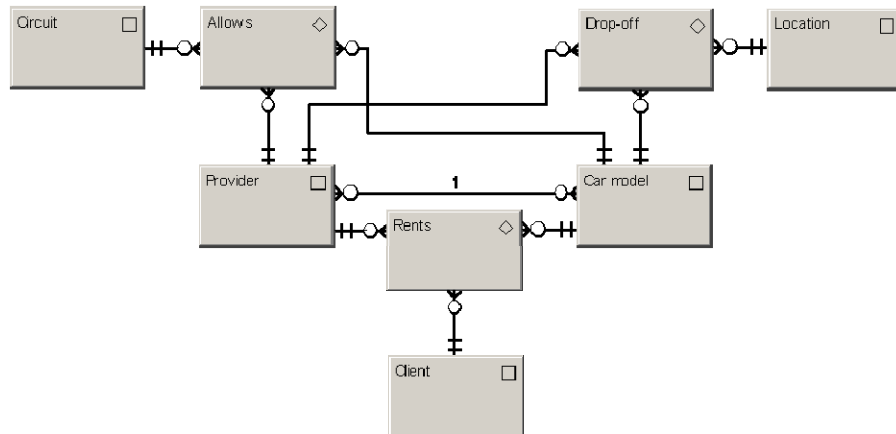
We begin with the definition of terms used in the later characterization of the service. Let us define the parts involved in the service first:

- An object of category (**#Provider**) is any agent (person or company) acting as a service provider.
- An object of category (**#Client**) is any person holding a valid driving license interested in the service.

Next, we describe the domain of the service by means of the following conceptual model M (see Figure 4 for its diagram):

- An object of category (**#Car model**) is any particular design or version of a car.
- An object of category (**#Circuit**) is any course suitable for car racing.
- An object of category (**#Location**) is any particular place.
- An object of category (**#Rents**) is any representation of relationship among a provider, a client and a car model, with the following meaning:
(#Client)-s who have rented a car of a given (#Car model) from a given (#Provider). / 0,M:0,M
- Relationship 1: (#Car model)-s offered for rent by a given (#Provider). / 0,M:0,M

Figure 4 Car Rental Service – the diagram of the model M .



8.2 Service Characteristics

Next, we need to define service characteristics important for the intended service client (or clients). It means we probably have to determine these characteristics in co-operation with the client(s).

Let us assume that the provider aims to focus on clients who intend to use the rented car for any of the following purposes:

- travelling (with the starting location same as the drop-off location),
- one-way travelling (with the drop-off location different from the starting location),
- renting a car to experience driving a racing car on a race circuit.

Each purpose may determine several requirements on the proposed service. These requirements indicate which of the possible service characteristics are important for the client when deciding whether or not to rent a particular car from the provider. In this example, we have derived the following characteristics:

Qualitative characteristics:

- Q_1 : A service is a car rental service, i.e. it conforms with the aforementioned model M .
- Q_2 : (**#Circuit**)-s which can be attended with a car of a given (**#Car model**) rented by a given (**#Provider**).
- Q_3 : (**#Location**)-s where a car of a given (**#Car model**) rented by a given (**#Provider**) can be dropped off.

Quantitative characteristics:

- Q_4 (max speed) is the maximum speed in miles per hour achievable by a car of a given (**#Car model**).
- Q_5 (rental rate) is the total rental rate in USD (including taxes) of a car of a given (**#Car model**) for one day requested by a given (**#Provider**).

8.3 Value Proposition

The formalized value proposition of the Car Rental service is based on the aforementioned characteristics, more precisely:

$$VP_S \subseteq Q_1 \times Q_2 \times Q_3 \times Q_4 \times Q_5$$

The value proposition is, for instance, the following (in case there are no model population constraints for a given characteristic, we omit them for better readability):

$$VP_S = \left\{ \begin{pmatrix} 1 \\ 0 \\ (1, C_1) \\ 90 \\ 45 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ (1, C_1) \\ 80 \\ 40 \end{pmatrix}, \begin{pmatrix} 1 \\ (1, C_2) \\ 0 \\ 120 \\ 399 \end{pmatrix} \right\}, \quad \text{where}$$

$$C_1 = (\text{\#Location}) = \{\text{any city in Georgia, U.S.}\}$$

$$C_2 = (\text{\#Circuit}) = \{\text{Road Atlanta}\}$$

How do we interpret this value proposition? VP_S offers three variants of the service:

- renting a car which can be dropped off at different than pick-up location, more specifically at any city in Georgia, U.S., with maximum speed of 90 mph for \$45 a day,
- the same as the previous variant, except the maximum speed is 80 mph and the rental rate \$40 a day,
- renting a race car with allowed access to Road Atlanta road course with maximum speed of 120 mph for \$399 a day.

8.4 Determining Acceptability

Consider a client c deciding whether or not to use the Car Rental Service. The client applies the following utility function to the value proposition:

$$U_S(q_1, q_2, q_3, q_4, q_5) = \begin{cases} 100 - q_5 & \text{if } q_1 = 1 \text{ and } q_3 = (1, C_3) \text{ and } C_3 \text{ conforms with } ((\# \text{Location}) = \{\text{Atlanta}\}), \\ 0 & \text{otherwise.} \end{cases}$$

This utility function expresses the fact that the client wants to rent a car which can be dropped off in Atlanta. The cheaper the service is the better. The client does not care about the remaining characteristics.

Let us assume that the client's acceptance interval is $I_c = (60, 100)$. Then the evaluation of U_S on VP_S elements renders the values 55, 60, 0. Because $60 \in I_c$, the VP_S is acceptable for client c .

In real world, client decisions can change at any moment, how is the acceptability determined in this case? Client decisions are modelled by the utility function, therefore the utility function has to be updated to reflect current needs of the client. Similarly, different versions of the utility function can be maintained to model different client profiles.

9. Indexing Services

Indexing of services can be utilized when there is a need to find a service matching given criteria; for instance, in *service broker algorithms* or in *service portfolio management*. Those criteria may be, more or less conveniently, expressed by a vector of service characteristics.

Consider value proposition of a service *without* model population constraints and quantitative characteristics. We can use this simplified vector of 0 and 1 values to build a *bitmap index* of services according to their (qualitative) characteristics. This index provides means for searching for services according to their value proposition.

Expressing search criteria as a vector of 0s and 1s enables easy and fast combination of different criteria by using logic operations. Furthermore, it is possible to extend this method to similarity search by relaxing the exact comparison of selected vector elements. On the other hand, search results have to be refined by taking the previously omitted quantitative characteristics and model population constraints into account.

10. Conclusion and Future Work

We have introduced semi-formal definitions of the *value proposition* and the *acceptable value proposition* built upon the *utility function* and formalized versions of service science basic concepts – the *service system* and the *service*. The semi-formal description is based on the HIT conceptual modelling method which concentrates on providing unambiguous semi-formal definitions of all model elements. The presented approach enables further research of service systems, especially in the following areas:

Service system modelling – we plan to develop tools supporting modelling of service systems from the point of view of the value proposition. This effort should result in the prototype of a computer-aided service system design tool.

Service composition/decomposition – the presented technical formulation of the value proposition can be utilized in computer-aided service composition and decomposition. The mapping of service characteristics onto the components of models of a service enables to *annotate* services with their contribution to the overall value proposition. These annotations can be utilized to assist in the design of service which utilizes existing assets maximally.

Service system optimization – another goal of our research is to provide assistance in the innovation of existing service systems which should be value proposition-driven. Otherwise the service provider might end up delivering a service which no client wants. We seek to investigate possible incorporation of the value proposition into existing software development approaches in order to achieve system optimization process which is (as much as possible) sustainable in terms of maintaining the value proposition acceptable.

We believe this paper presents only the beginning of further research which will contribute to the inter-connection of service science and computer science disciplines.

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