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Towards an Ontology of Value Ascription

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Abstract. The analysis of value, value ascription mechanisms, and their motivating and influencing factors is useful for decision making processes of both customers and providers. In particular, enterprise modeling can greatly benefit from a proper understanding of value-related notions. Nonetheless, existing value models mainly focus on the value exchange between subjects, disregarding the understanding of "what" value is and of "why" something is valuable. In order to exploit the benefits of value analysis, a precise and rigorous conceptualization, based on foundational ontologies, is needed. To this aim, we present and discuss here a preliminary core ontology of value ascription and we discuss the main issues.

Keywords. Value modeling, ontology, value ascription, enterprise modeling

1. Introduction

To find out and put the right value on a thing is both easy and hard. It is easy in the sense that anyone has the freedom to decide on that, but it is hard in that a valuation rarely holds for all and for all times, as in general a valuation process may be terribly complicated, and inherently subjective and context dependent [1]. Indeed, although the concept of value has always raised the interest of economists, philosophers and sociologists, it remains "perhaps the most ill-defined and elusive concept in service marketing and management" [2, p. 2], becoming "one of the most overused and misused concepts in the social sciences in general" [3, p. 428]. No surprise then that there exists an abundance of views on value, all relevant in their own ways.

We shall focus in this paper on the notion of economic value, and in particular on *use* value, in the context of enterprise modeling. Note that we shall not attempt to *define* such notions, relying to a great extent on an intuitive understanding. Rather, we shall focus on the *value ascription* relationship holding between a *agent* and a *value object*. In particular, we shall explore the ontological assumptions behind value ascription, i.e., what should exist when one says that someone (an agent) ascribes a value to something (a value object) in a particular context.

In a very different way, others have done similar investigations. Take for example OMG's *Business Motivation Model* [4, p. 2], whose two main areas of analysis are described as follows:

- "[...] the *ends and means* of business plans. Among the *ends* are things the enterprise wishes to achieve (for example, *goals* and *objectives*). Among the *means* are

things the enterprise will employ to achieve those *ends* (for example, *strategies*, *tactics*, *business policies*, and *business rules*)."

- "the *influencers* that shape the elements of the business plans, and the *assessments* made about the impacts of such influencers on ends and means (i.e., *strengths*, *weaknesses*, *opportunities*, and *threats*)"

So, we can say that this Business Motivation Model is all about describing the elements that influence assessing the *value* of business objects, in various contexts, in the light of means and ends. A deep analysis of the basic value-related notions and the way they affect value ascription would be of great benefit for enterprise modeling, but the literature on value modeling ([5,6,7]) is still maturing, and we cannot today say that it is well integrated with more traditional enterprise modeling activities such as process modeling and organizational modeling.

The ontology presented in this paper differs from others mainly in its analytic approach. Leveraging on previous work on the ontology of relationships [8], we analyze the ontological nature of value ascription, its motivating aspects, and the underlying ontological assumptions. At the core of the assumptions there are those concerning *what* value is and *where* it is attached: is value something inhering in the value object, in the agent's mind, or perhaps in the relationship between the agent and the value object?

We shall focus on these questions while presenting our ontology, which is necessarily limited in scope. This is mainly for space reasons as a full ontology quickly becomes complicated due to the nature of the domain. Some important limitations should be mentioned: (a) it is assumed that there is a one-actor view (a user's or consumer's view) on value ascriptions. A producer's view is not included, for example, and neither are value adjustment processes such as negotiations dealt with. (b) It is assumed that the value objects are economic ones. That is, they are tradable in whole or in part. Typical examples are goods or services. We do not include objects like societal institutions in this analysis. (c) It is assumed that value ascriptions are taken place in, are influenced by, and are influencing various contexts. However, we do not analyze context in any detail but simply refer to it.

The remainder of the paper is structured as follows. In Sec. 2 we discuss the related works and in Sec. 3 we analyze the phenomenology of value ascription. In Sec. 4 we present and describe a draft of an ontology of value ascription. Finally, we analyze the core issues behind our modeling choices (Sec. 5) and draw our conclusions (Sec. 6).

2. Related Work

2.1. Multiple Axiologies

A number of axiologies exist in the literature, also called value classifications or value theories. An axiology identifies a set of values and relates them to each other through a classification and/or taxonomy. One well-known axiology is the one proposed by Schwartz [9], which identifies ten top level values: universalism, benevolence, conformity, tradition, security, power, achievement, hedonism, stimulation and self-direction. These values are then organized based on motivational similarities and dissimilarities. Other widely used axiologies are those by Sheth et al. [10] and Holbrook [1].

As the mechanisms of value ascription do not depend on the specific values being ascribed, it is for the purposes of this paper possible to remain agnostic about the choice of a specific axiology. In other words, the ontology proposed does not take a stance on which axiology to use.

2.2. Value Modeling

Several approaches have been developed in value modeling literature, such as the Resource, Event, Agent (REA) Ontology [5], e3value [6], and, more recently the Value Delivery Modeling Language (VDML) [7].

The REA ontology describes economic transactions and internal processes by means of some basic constructs related to organizations, such as resource, event and agent, with the aim of developing Accounting Information Systems (AIS). Although REA is concerned with business transactions, only the price and not the value of the resources and exchanges is accounted for.

e3value is an ontology-based methodology for defining business models for business networks [6], commonly used for the modeling value exchanges. It adopts the economic value perspective by representing what is exchanged and by whom [11]. The e3value ontology is based on the principle of reciprocity emphasizing the dual character of business transactions. This "give and take" approach denotes that every actor offers something of value, such as money, goods, services, etc., and gets a value in return. However, e3value focuses on the exchanged value among actors, leaving out the analysis of why value is exchanged, thus stakeholders' goals [12] or other aspects such as commitments and organizational structures. It defines value object in an abstract way, without further analysis of its nature or that of the actors that exchange it.

The Value Delivery Modeling Language (VDML) aims at supporting the "recognition and understanding of problems and opportunities in the context of market demand and enterprise optimization" [7], accounting for several viewpoints: value networks, value streams, REA, e3value and the Business Model Ontology. However, value is seen as a "measurable characteristic". In general, "value models do not describe the why" [12, p. 2] and they do not help clarifying what value is.

3. The Phenomenology of Value Ascription

According to Gloria Zuñiga, value is "a significance attached to a good resulting from a conceptualization of the good in terms of a desired end. Such a conceptualization can be characterized as an interested evaluation, since the agent perceives a causal connection between the possession of the good and the fulfillment of an end" [13, p. 306]. With this definition, Zuniga excludes final value from the analysis, and only addresses instrumental value (or non-final value).

There is an implicit *phenomenology of value ascription* behind this definition. First of all, value emerges in a relational context, involving at least an agent besides the good. We shall say that value is *ascribed* to the good. Second, value depends on the existence of a *desired end* in the agent's mind, which in most cases is the optimal combined satisfaction of multiple (possibly conflicting) desires. Third, there is a perceived *causal connection* between the good and the desire, so that the good is conceptualized as (some-

how) instrumental to the fulfillment of the desire. Finally, since our agents are *situated*, it seems plausible to assume that the agent's desires depend somehow on the external context (both concerning their strength and their very existence).

Zuñiga's definition is clearly oriented towards the so-called goods-dominant perspective [14]. In this paper we shall adopt the generic term *value object* (already introduced by Weigand and colleagues [15]) to denote anything we can ascribe a value to, being it a good, a service, or possibly something else (as will be discussed).

Let us see now how we can describe in ontological terms the phenomenology of value ascription. According to the BDI approach [16], the mental state of an agent is characterized by beliefs, desires, and intentions, which in turn depend on the broader physical and social context to which the agent belongs. Having a certain perception of a value object in a particular context, the agent may believe that the object, thanks to some of its *qualities*, can be instrumental to the fulfillment of a desire about the realization of a certain state of affairs. While believing so, we may say that the agent *ascribes* to the value object a *further* quality, namely its *value*. Note that we are using here the term 'quality' in an informal sense, which will be clarified later in the paper. In any case, it is important to observe that, although we say that this is the value *of the object*, it would be inaccurate to see ascribed value as a new entity, a special kind of quality that inheres *in the object* in addition to its ordinary qualities, such as shape, color, mass, and so on. This is because, after all, there is nothing in the object besides its ordinary qualities when it is evaluated by a subject. On the contrary, certainly something happens *in the agent* when she is involved in an evaluation relationship, since the object's value is somehow encoded in the agent's mental state. This is why, in the following, we shall model ascribed value as an entity (a *relational quality*) inhering in the agent, expressing the agent's *attitude* towards a specific object.

The ascribed value is *existentially dependent* on the value object, and it comes into existence when an *evaluation relationship* is established. Note that such relationship may last in time. During this time, it seems natural to assume that the ascribed value maintains its identity while changing its *magnitude*. The distinction between value and its magnitude is an important one, already present in Marx, which fits nicely with the ontological notion of quality we shall rely on, described in the next section. The ascribed value's magnitude is ultimately depending on how well the object's qualities *fit* the agent's desires, but is also affected in a complex way by a number of factors. In synthesis, we should at least take into account:

- the agent's desires and preferences, which in turn may depend on the context, or more exactly on the various relationships the agent may have with the context (e.g., while playing various roles);
- the benefit of the value object for the agent, which depends on the capability of the object to contribute to the satisfaction of the agent's desires, which in turn depends on the object's qualities;
- the costs that, independently from the value object's intrinsic qualities, the agent necessarily faces for physically accessing and using the object to actually realize her desires (for instance, if the value object is a bus service, the cost of reaching the bus stop).

The last point deserves a clarification. In general, we can say that the final value is ultimately a trade-off between benefits and costs. However, it is important to stress that

such costs are not to be confused with the value object's *price*. Indeed, the *use costs* of an object are independent from its price. The latter represents the cost necessary to acquire the *right* to use a particular value object, while the former represents the costs that are necessary to use it. For instance, the use costs of a bus service may include the time needed to reach the bus stop.

Looking at the three points above, it is easy to see that, although a rational value analysis may in principle be possible, we can hardly assume that ascribed value is just the result of such an analysis, because the required information may not be all cognitively accessible (think for instance of each single desire's strength), or simply because the evaluation process may be very complicated, especially in the presence of multiple, potentially conflicting desires. This is one of the reasons why the literature distinguishes between *perceived value* and *utilitarian value*. In ontological terms, as we shall see, this means that the only *ascribed* value, from the phenomenological point of view, is the perceived value, which we see as a quality inhering in the agent. The utilitarian value, on the contrary, does not inhere in the agent nor in the value object, and simply emerges from a very complex comparison relationship ultimately involving the agent's desires and preferences, on the one hand, and the object's qualities, on the other hand. In a sense, this is a *theoretical valuation relationship*[2], which exists independently of any actual evaluation process being intentionally performed by the agent.

4. First Modeling Choices

In this section, we present a preliminary model of the Value Ascription Ontology, which was designed taking as basis the Unified Foundational Ontology (UFO) [17,18]. UFO is a foundational ontology developed with an interdisciplinary approach inspired by Formal Ontology, Philosophical Logic, Linguistics, and Cognitive Psychology. It is based on DOLCE [19], OntoClean [20], and GFO/GOL [21].

The main reasons why we decided to adopt UFO are three. First, UFO shares with BFO [22] and DOLCE the notion of *individual quality*, but has a specific treatment of *relational qualities* that is specifically suited to our purposes. Second, as we said, the present work relies heavily on the ontological analysis of relationships, based on the notion of *relator* initiated originally in UFO and recently revised by Guarino and Guizzardi [8]. Indeed, we see this paper as a sort of test to experiment with the expressive power of relationships as a genuine ontological category. Finally, a nice feature of UFO is the OntoUML environment built on top of it, which allows for an ontology visualization more or less understandable also by people who only know the basics of UML modeling, and provides an effective tool for consistence checking and semi-automatic verification of intended models. In the following, we shall first illustrate these three points, and then outline the structure of our ontology.

4.1. Relational Qualities and Ascribed Value

Individual qualities (qualities for short), originally introduced in the DOLCE ontology [23], are now a common feature — with minor differences -– of top-level ontologies such

[2]In the following, we shall call 'theoretical value' the value emerging from such relationship. Other candidates might be 'utilitarian value' or 'actual value', but we prefer to avoid conflicts with other connotations.

as DOLCE, UFO, and BFO . Intuitively, we can see qualities as specific aspects of things we can use to compare them. Qualities *inhere* in things, where inherence is a special kind of existential dependence relation, which is asymmetric and functional [24]. Qualities are distinct from *qualia*, which are abstract entities representing what exactly resembling qualities have in common. Qualia resulting from comparable individual qualities are considered as regions of *quality spaces*; each quality kind has its own quality space. At different times, qualities can keep their identity while occupying different regions of their quality space; they are considered therefore *endurants* in UFO.

In UFO, qualities belong to the more general class of *intrinsic moments*, which includes also *modes* such as a thought, a belief, or an intention. Among modes, there are *externally dependent* modes, such as a particular mental attitude towards another person or object, which are existentially dependent on something else besides their *bearer* (i.e., the entity they inhere in). This notion of externally dependent mode seems to us particularly suitable to capture our intuitions concerning ascribed value.

In the following, in line with a choice made in [8], we shall collapse the distinction between qualities and modes, just talking of qualities, while introducing the term *relational quality* for externally dependent qualities. So, as we shall see, we shall model ascribed value as a relational quality. This choice stresses the fact that, similarly to standard qualities, relational qualities may change in time by changing the region they are located in their quality space. In our case, since its quality space is a semi-line, ascribed value can change in time by changing its *magnitude*.

4.2. Relations and Relationships

In a recent paper, building on previous work on the notion of *relator* [24], Guarino and Guizzardi proposed a novel ontological analysis of relations and relationships based on the re-visitation of a classic problem in the practice of conceptual modeling, namely relationship reification [8]. In the paper, the authors argue that, while a relation is usually intended a set of tuples, a relationship should be considered not as a tuple (i.e., an ordered set of objects), but rather an object in itself, that needs to exist in the world in order for a relation to hold: relations *hold* (i.e., relational propositions are true) in virtue of the existence of a relationship; relationships are therefore *truthmakers* of relations. While discussing the possible choices concerning the nature and structure of such truthmakers, the authors focus on a relevant class of relations, so-called *extrinsic relations*, which can not be derived from the intrinsic properties of their relata – *married with* is the prototypical example. For these relations, they show that the corresponding relationships can be understood as mereological sums of relational qualities: for instance, a marriage can be understood as a sum of mutual commitments and obligations. An advantage of such position is that, since qualities are assumed to be *endurants* (i.e., entities that may change in time while maintaining their identity), relationships are endurants as well, whose behavior in time accounts for the *way* a relation holds in time.

In this paper, building on ongoing unpublished work[3], we extend the above approach to include a crucial relation for our purposes, namely the one holding between an agent

[3]In this work, presented at an ER2015 tutorial, Guarino and Guizzardi showed that the approach of [8] can be generalized to so-called descriptive relations, that hold in virtue of some qualities of their relata. Comparative relations hold in virtue of non-relational qualities, while extrinsic relations hold in virtue of relational qualities. This means that, while extrinsic relationships are mereological sums of relational qualities, comparative relationships are mereological sums of non-relational qualities.

and a value object when such an object has a certain value for the agent. This can be seen as a comparative relation, that holds in virtue of the mutual distance (degree of fit) between the object's qualities and the agent's desires and preferences. So, the truthmaker of such a relation will be the mereological sum of the object's qualities plus the agent's desires and preferences.

4.3. OntoUML

In our proposed value ascription ontology we will closely adhere to the semantics of OntoUML. OntoUML [17] is an extension of UML that incorporates the basic ontological distinctions made in UFO in the form of UML stereotypes. Stereotypes (enclosed between $\ll \gg$ symbols) indicate the meta-category (kind of universal) to which a certain UML class belongs, constraining in this way its semantics according to the UFO ontology.

The intended semantics of such stereotypes is described elsewhere [17], [25]. The basic kinds of universals we shall use in our model are *kind*[4], *role* (both subclasses of *sortal universal*), *category*, *rolemixin*, and *mixin* (all subclasses of *mixin universal*). In addition, we shall use the stereotypes *relationship kind* and *quality kind*. Note that we decided to put the word 'kind' in their names, to better convey their nature of meta-categories (kinds of universals), avoiding confusions with kinds of particulars.

4.4. The Value Ascription Ontology

We shall now briefly discuss the ontology represented in Fig. 1. We will analyze each one of these concepts in Sec. 5. The graph is roughly structured like this: along the horizontal dimension we express the relation between the the agent and the value object. Along the vertical dimension we indicate the aggregation of theoretical value, as well as the evolution from the agent's desires and preferences to the perceived value.

At the core of our diagram there is the *theoretical valuation relationship*, that *involves*[5] three entities: an *agent* (which here we assume to be just a person), a *value object* (e.g., an economic resource), and a *context*. This relationship, that ultimately expresses the 'degree of fit' between the object's qualities and the agent's desires and preferences, results in turn from the aggregation of *several* valuation relationships (note the cardinality constraints) belonging to two different kinds: *cost specific valuation* and *benefit specific valuation*.

These two kinds of relationships express the different ways in which the object's qualities are compared against the agent's desires and preferences. Each of them aggregates exactly one desire and one or more object qualities. The 'positive' qualities appearing in a benefit-specific valuation are different from the 'negative' ones appearing in a cost-specific valuation, although in the model we don't distinguish explicitly between the two. In addition, each valuation relationship may also aggregate one or more preferences (discussed below in more detail). Finally, desires and preferences may depend on context, or, more exactly, on the various *context involvement relationships* an agent may have with the context while playing various roles.

[4]Used as a stereotype name, 'kind', consistently with the UFO terminology, denotes a universal that is rigid and supplies a principle of identity. Elsewhere in the paper we use the same word also in its generic sense

[5]*Involvement* is here a *formal relation* analogous to what has been called *mediation* in [24].

Each cost-specific or benefit-specific valuation relationship has a *value quality* attached, whose magnitude emerges (in a complex domain-specific way that is not discussed here) from the actual object's qualities, desires and preferences that constitute the relationship. This is similar to what happens, say, for the spatial relationship involving two physical bodies, whose distance emerges from their location qualities. The *theoretical valuation relationship* has also a value quality attached, but in this case two explicit dependence relations have been put in the model, to account for the different ways cost value and benefit value contribute to the final theoretical value.

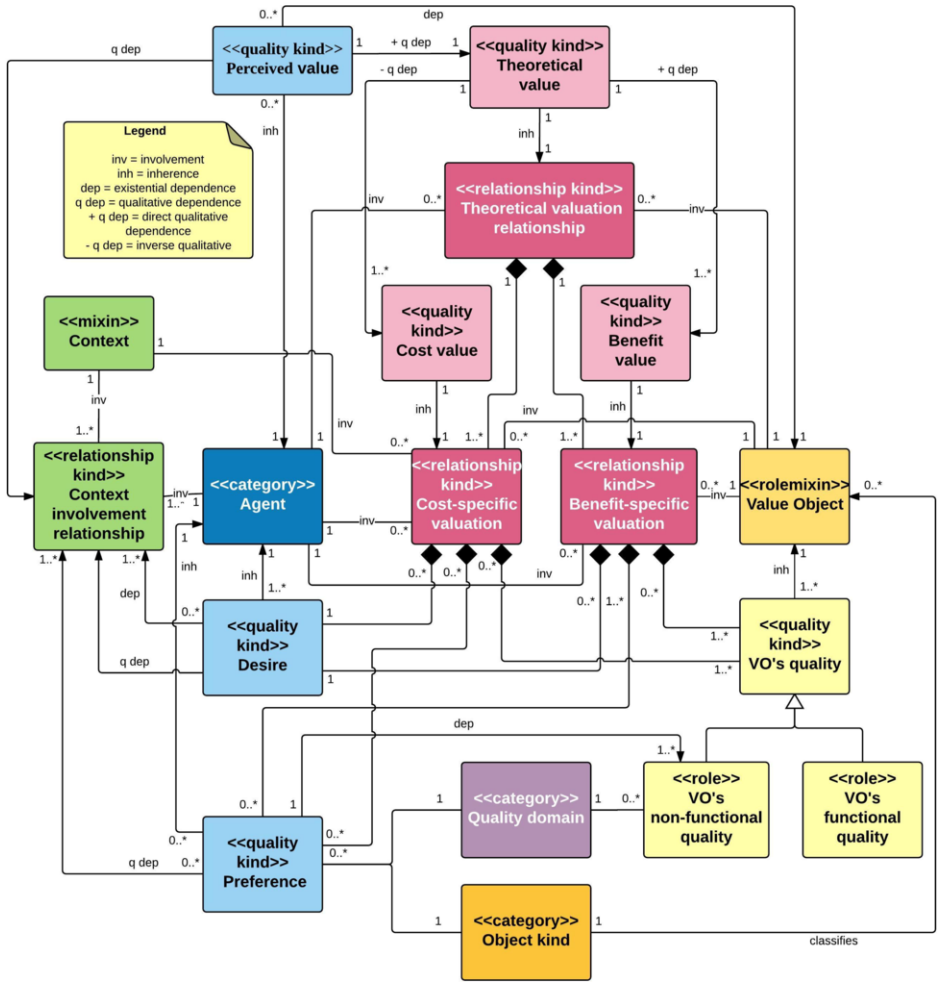

Figure 1. The Value Ascription Ontology

5. Core Constructs and Issues

In this section, we will discuss the core constructs and issues related to modeling value ascription.

5.1. Value Objects and Their Qualities

Value can be ascribed to different kinds of entities; when value is ascribed to an entity, this entity plays the role of *value object*. Potentially, all entities can be value objects, including economic resources (e.g., goods and services), economic offerings, actions, states of affairs and social relationships (e.g. LinkedIn or Facebook contacts, hiring relationships, or service commitments).

In the model presented in Sec. 4, we focus mainly on *economic resources*, i.e. entities that can be traded and used by an organization or a person for the satisfaction of their goals (e.g., cars, transport services, mail services, consulting services, etc.). However, a more general model should also account for other types of value objects, which we briefly discuss in the following.

Economic offerings are conditional commitments towards a target community. These commitments are bidirectional and include aspects such as price, actions that need to be taken by a provider, delivery options, warranty and, in general, complementary commitments and claims as defined in [12] and [25]. We include in economic offerings both good and service offerings. With *service offering* we mean that a provider offers to establish commitments with a customer, which can be carried out by certain activities. For *good offerings*, someone offers to transfer the ownership of some goods to a customer. In this case, there may be complementary offerings concerning how to deliver the goods.

It is important to remark that the value of an offering is obviously very different from the value of the economic resource offered. Let us think about the purchase of a laptop. An agent will evaluate the laptop for its characteristics and for its ability to satisfy the agent's desires and preferences (evaluation of an economic resource). The agent may also evaluate a broader set of things, such as the possibility to have an extended warranty or to purchase a set of accessories together with the laptop at a lower price, the delivery possibilities – in terms of speed and convenience – and the easiness to purchase it. In this case, the agent is evaluating the *offering* rather than the single economic resource.

With respect to *actions*, the preference theory developed by Sen [26] is particularly relevant. This theory distinguishes between *culmination outcomes*, where only the final outcome of a certain process determines the value judgment, and *comprehensive outcomes*, where the process that brings to the outcome is considered as well. This distinction clearly emerges from the fruit choosing example discussed in [27]. The example shows how an individual that, in general, prefers mangoes to apples, in specific social conditions can choose to take an apple instead of a mango because, for instance, there is only one mango left. In this case, it is not the outcome per se that drives the choice of the individual, but rather a series of conditions affecting the decision process (e.g., the number of fruits available and the social circumstances). Nonetheless, the same individual would still appreciate if somebody would give him the mango, without asking him. So, the value of an object (the mango) is clearly different from the value of an event (an action) involving such an object.

In other words, ascribing value to economic resources is very different from ascribing value to the actions performed to obtain them. In the previous example, the mango

has the same value regardless of the external circumstances (who is choosing, how many mangoes there are, etc.), but the value of the action needed to acquire its possession and ability to use changes. The beneficiary's action is more strongly related to the context, and, as such, also to ethical concerns. The previous example brings to light the need to discern who is performing the action, i.e., whether it is the beneficiary, the provider or a third person.

Social relationships include things such as the value an employer assigns to the business relations of a salesman or the value that a company assigns to customer loyalty. For instance, Apple ascribes value to the fact "Nicola likes his MacBook", since, under certain circumstances, this fact will translate in Nicola's propensity to buy a new MacBook model in a future point in time.

It is also possible to assign value to *states of affairs*; for instance a person may assign a value to the state in which she owns a Picasso painting, though the painting will not be "used" and maybe not even looked at every day.

For the purpose of this paper, we focus only on economic resources, and we disregard economic offerings, actions and social relationships. Nonetheless, in the ontology we consider value objects as *rolemixins*, since the role can be potentially played by several kinds of entities.

Value objects are characterized by a set of *qualities* inhering in them. Such qualities can play two different roles in the value ascription process. A quality plays a *functional role* when it has to satisfy a specific constraint in order to satisfy a certain desire. For instance, the maximum number of allowed passengers may play a functional role in evaluating a car for a person with three kids, since, say, small cars accommodating only four passengers would be of no value for her. A quality playing a *non-functional role*, instead, is a quality that does not have to satisfy a specific (yes or no) constraint, but anyway is taken into account in the value ascription process, because it is associated to a personal preference. A typical example of non-functional quality is color. Note that the two roles are not disjoint: for instance, the person described above may also give a non-functional relevance to the maximum number of allowed passengers, preferring cars that accommodate as many passengers as possible.

5.2. Agent, Context and Role

In general, the agent of a value ascription process may be either a physical person or an organization, such as an enterprise. In this paper we considered 'agent' just as synonym of a physical person that can ascribe value to a value object, thereby participating in a value ascription relationship. So the class *Agent* is stereotyped as an OntoUML *kind*. When an agent ascribes value, she will be influenced by a number of various factors, including location, environmental conditions, social situation, and the role she plays in that situation. In other words, a value ascription will depend on the context and social roles of the agent.

A social role is always played in relation to a context, e.g., a movie watcher at the movie theater, a movie watcher at home, or before and after having watched a movie. With context, on an abstract level, we mean "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" [28]. For what concerns value one can distinguish a general

context (e.g., cultural background and social rules recognized by the agent) that affects an agent's preferences, and a more situation specific context that affects value in the moment in which it is assigned (e.g., social situation). Included in the context are:

- *norms and social rules*: social rules that hold for a community of agents and affect the external manifestation of personal preferences. We can distinguish:
  - norms: informal representation of group conduct. In the mango example, it is acceptable for the chooser to pick the mango if more than one is available, but not if there is only one left.
  - contextual social rules: different sets of social rules that may apply to the same agent in different contexts, e.g., it may be forbidden to appreciate a cigar in a public place whereas it is allowed at home;
  - cultural background: social rules that are embedded in the agents and affect their behavior, regardless of the context.
- *physical and mental conditions of the agent*: for example, other things being equal, a stressed or sick person could assign a lower value to a product, due to a different rating of the goals;
- *location*: for example, if a person is in the desert, then the perceived value of water is higher;
- *environmental conditions*: for example, temperature, time of the day, and season;
- *product availability*: the availability and scarcity of the value object on the market and whether the agent is already in possession of the (kind of) objects to which she is ascribing value.

In our model, the *Context* class is stereotyped as a *mixin*, as it may include classes with different meta-properties. The various relationships involving an agent and a context are represented by the *context involvement relationship*. Let us suppose Mary plays the social role of "literature professor", and that she is currently at her office. Then she, as a professor, would be related to the office context. This relationship indirectly affects the value ascription process. This can be clarified if we consider the case in which Mary is not only a professor but also a"book reader". When Mary recommends a set of books to her students, she appreciates the books with respects to the two roles she plays, so she may like a book for its story, but she may think that book is insufficiently educational for her students.

5.3. Value and Value Ascription

We can see the relationship between an agent and a value object as a complex configuration of desires and preferences, from the agent's side, and functional/non-functional qualities, on the value object's side. We see what we called *theoretical value* as an attribute of such configuration, whose actual magnitude results from a trade-off between multiple benefit-specific and cost-specific values, each one evaluated with respect to a specific desire. Such trade-off is represented in the model by formal relations labeled *-q dep* and *+q dep*, respectively to indicate an *inverse (or negative) qualitative dependence* and a *direct (or positive) qualitative dependence*. For example, *-q dep* means that the higher the *cost specific valuation* is, the lower the *utilitarian value* becomes.

As we have seen, the *theoretical valuation relationship* is the 'final' relationship between an *agent* and a *value object*. It is an aggregation of all the relationships that account for the costs of using or having control of a value object, as well as the benefits of having it[6]. Due to the complexity of such relationships, computing the theoretical value could in principle require an omniscient being with potentially infinite cognitive resources, so that in practice only approximations of the theoretical value may be actually encoded in a human brain.

Finally, the agent ascribes a *perceived value* to the *value object*. This *perceived value* is dependent on the *theoretical value*. Colloquially, it is the agent reflecting on its own utilitarian behaviour. It is here assumed that the agent is well informed and in a rational state of mind so that he or she is actually able to take the utilitarian value into account, though this will always be done in a partial and provisional way. We note that although the theoretical value may stay the same, a perceived value can (and often does) change. This is typically what happens when a person decides that a particular coat is no longer nice to wear, for example. In addition, perceived value is typically influenced by the price.

5.4. Desires and Preferences

When an agent ascribes value to something, she certainly takes into account her own desires, but also her own preferences take a (usually secondary) role. For instance, a person can ascribe value to a particular car on the basis of its technical specifications, but may prefer a color over another, even being prepared to give up some technical features. In UFO ontology, desires and preferences would be considered as particular kinds of *modes* (in the UFO's terminology), corresponding to *conative attitudes* [29] that inhere in the agent. However, since they both have a *strength*, we consider them as qualities, collapsing (for the sake of simplicity) the UFO's distinction between modes and qualities.

More in detail, we assume (as usual) that desires are *propositional attitudes*, so each of them has i) a *content* that is a proposition describing the desired state of affairs, and ii) a *strength*, which accounts for the relative priority of desires. Preferences are less analyzed in the ontological literature. We see a preference as a complex mode (quality) involving i) a *structure* imposed on a quality domain, i.e. a partial ordering relation covering such domain, and ii) a strength, which accounts for the relative priority of preferences. Based on the preference strengths, we can have for example an ordering like (status, productivity, convenience), which means that the status impact of a certain product is the most important preference dimension, followed by productivity and then convenience.

In our model, we also assume that desires and preferences depend on context. More exactly, they depend on the way an agent is involved in a context, i.e., on the *context involvement relationship* (which in general will be a role playing relationship). As shown in the diagram (Fig. 1), a single desire is assumed to be existentially dependent on a particular context involvement relationship (for instance your desire of a cold drink

[6]A variant of such notion of theoretical value would be a value ascribed *for* one agent by another agent, i.e. one agent could assess the value that a certain object has for another agent. For example, Peter could consider a certain bottle of wine of high value for John, while Liza could consider it of low value for him. So different agents could maintain different different judgments concerning the value certain objects have for others, resulting from differences in their information and cognitive abilities, as well as personal attitudes.

while climbing a mountain in the sun). We have also introduced a formal relation labeled *qdep*, standing for (*qualitative dependence*, holding between a quality and a relationship, meaning that either a direct or an inverse qualitative dependence holds with respect to some of the qualities that are part of the relationship. We assume that both desires and preferences are qualitatively dependent on the context involvement relationship, in the sense that their strength may be influenced (either positively or negatively) by the magnitude of some qualities that are part of the context involvement relationship. We also assume that each preference structures the domain of a non-functional quality of the value object, and that, for each non-functional quality, there is an associated preference. Finally, we assume that each preference is associated to exactly one object kind, so that, say, agents are assumed to have different preferences for objects of different kinds.

6. Concluding Remarks

In this paper we have presented an initial proposal for an ontology aiming at understanding the nature of the value ascription relationship. We learned a lot from our modeling attempt, understanding in particular the mechanisms of aggregating benefit-specific and cost-specific values coming up with the notion of utilitarian value, which is different from that of perceived value. While the specific ontology proposed is certainly to be refined and extended, we believe that this paper can contribute to establish an analytic approach to value modeling, suitable to be of practical relevance for enterprise modeling in general.

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