Towards an Ontological Foundation of Services Science: The General Service Model

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ABSTRACT

Despite the ubiquity of services, there is still no consensus on their exact nature and structure. This consensus, however, is necessary to unambiguously describe and trade services physically as well as in an Internet of Service. To make some progress towards a shared conceptualization, we present in this paper a general service model based on the DOLCE foundational ontology. In our understanding, a service is essentially composed of a service process whose core actions (delivered by a service producer to a service consumer) comply with the exposed description of a service provider's commitment. Each service belongs to a larger service system process which obeys legal and pricing constraints. We illustrate the model's usefulness and relevance by the means of a continuous example.

Keywords

Service ontology, service model, foundational ontology, conceptual model, service science

1. INTRODUCTION

Nowadays services are everywhere. There are public services conceived to make life easier to the members of a certain community, like public residences for elderly. There are private services providing actions or processes we want to be performed, but we are unable or not willing to perform ourselves, so we pay someone else to do them, like car repairs. There are information services, which people pay for in order to be informed about something that they would not come to know otherwise, like online license registries. Further there are services which are sold in combination with products to augment the value of such products (e.g. a car combined with free check-up services) or even enable the use of these products in the first place (e.g. a mobile phone).

However, despite the pervasiveness of the term *service* in the ordinary discourse, there is no wide consensus on the meaning of such term; not only it is used in different ways across disciplines (e.g. economics vs. computer science), but even within the same discipline confusions and inconsistencies predominate.

Given such a situation, interoperability across services becomes a myth, since as service designers do not share a common semantic background, they may use the same terms to express different concepts or different terms to refer to the same concept [39; 50].

Our claim is that, in order to overcome the problem of service interoperability, we need a unified, rigorous, and principled reference ontology of services, able to clarify the intended meaning of the terms used and to make explicit how the domain of services can be structured.

Since many different perspectives on the services domain may be adopted, our choice is to build a reference ontology based on a rigorous ontological analysis, anchoring the primitives of the service domain to more fundamental primitives taken from a top level ontology, which is in our case the foundational ontology DOLCE [28]. We deem such a foundational perspective is necessary to substantiate a *services science* [7].

In the following section we review related work on service description efforts and how they can be categorized. In doing so, we highlight the shortcomings which motivated our research. In Section 3 we introduce the theory and approach we use throughout the remainder of the paper. We then elaborate on our general service model and substantiate it with the foundational primitives of DOLCE to demonstrate the validity of the constructs. We summarize the paper's contribution and put the model in relation to the emerging standard of the Unified Service Description Language (USDL) [42] to further underpin the necessity of the research.

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2. RELATED WORK

There exists a plethora of service description efforts that can be grouped into different strands. Each of these strands has its own motivation and representation needs for capturing service information. Each strand consists of standardized, academic, or proprietary efforts. The efforts can be roughly compared according to *scope*, e.g., whether the effort captures IT or business aspects of services or the whole service system. Another relevant criterion is the effort's *purpose*: is the effort geared towards normative data exchange, is it there to facilitate software engineering, is it there to automate a specific task, or is it there to act as reference model?

The first strand of service description efforts is the field of *Service-oriented Architectures (SOA)*. Typically their scope concerns the IT aspects of services only, e.g., the interface description. Different standards bodies specified several dozens of different aspects which are collectively known as WS-* (incl. WSDL, WS-Policy, WS-Security, etc.) mainly for the purpose of exchanging such information over the Web. Another effort in this strand is the Service-oriented architecture Modeling Language (SoaML) by (OMG) [36]. Its purpose is to support model-driven software engineering for services. Finally, there emerged the need to establish a Reference Model for Service Oriented Architecture (SOA-RM) which was published by OASIS [37]. An alternative reference model in the form of an ontology for SOA (SOA Ontology) is available by The OpenGroup [51]. Current research in the SOA strand mainly concerns RESTful services and their description (cf. WADL [19]). Oberle et al. [35] provide an ontological account of Web services according to the principles of ontological analysis on top of the DOLCE foundational ontology. The ontology can be regarded as a reference model with the scope limited to IT aspects.

The second strand consists mainly of ontologies in the field of *Semantic Web Services*. The main goal of Semantic Web Services approaches is automation of discovery, composition, and invocation of services in an SOA by ontology reasoners and planning algorithms. The most prominent efforts within this strand are OWL-S [27] and WSMO [40]. Many surrounding and similar efforts have surfaced in academia and most of them are geared at automation and limit their scope to IT and non-functional properties. Along the lines of SOA-RM, the community is working on a Reference Ontology for Semantic Service Oriented Architectures (RO-SOA) which is available as a draft by OASIS.

The third strand is rooted in the rise of on-demand applications that led to the notion of *Software-as-a-Service (SaaS)*. Here, the emphasis of service implies that the consumer gets the designated functionality. Thus, SaaS is not synonymous with SOA. The strand of SaaS contains a standard, namely, the W3C Service Modeling Language (SML) [56]. The anticipated purpose of SML is to define a consistent way for exchanging information about computer networks, applications, or servers so businesses can more easily manage the services that are built on these resources. Current research is represented by the Software-as-a-Service Description Language (SaaS-DL). SaaS-DL builds on WS-* to capture SaaS specificities in order to support model-driven engineering [49].

The fourth strand focuses on capturing the purely *economic* aspects of services regardless of their nature. The DIN PAS 1018 standard essentially prescribes a paper form for the description of services for tendering [10]. The structure is specified in a non-machine-readable way by introducing mandatory and optional non-functional attributes, such as, classification, resources, location, etc. O'Sullivan [33] adopts a wider scope and contributes a domain independent taxonomy which is capable of representing the non-functional properties of conventional, electronic, and web services. Toma [53] presents a syntactic translation of O'Sullivan's work in the proprietary WSML language. Emmich [13] focuses on product-related services, such as maintenance, and is specified in UML. He basically merges existing standards and models for products, companies, organization, and resources. Finally, the Unified Service Description Language (USDL) is a proposal to unify the business and technical scope of services [5; 6].

The fifth strand is also focused on economic aspects but draws attention mainly to describing *service networks*, i.e., the ecosystem and value chain relationships between services of economic value. So far, this strand is represented by academic approaches mainly by Akkermans research group. The latter brought forth several ontologies, among them the Obelix and Serviguration ontologies which exhibit a clear business scope. The latest effort is the e^3Service ontology which models services from the perspective of the user's needs [9]. The main purpose is to generate service bundles under the consideration of customer needs. The Service Network Notation (SNN) captures similar aspects to the e^3Service ontology [4]. However, SNN is a UML model for the purpose of analyzing measurements of added value for each single participant as well as for the whole network optimization of value flows.

Finally, there are overarching efforts that concentrate on the bigger picture of *service systems* or service science also taking into account value co-creation, i.e., the sharing and distribution of labor, investments, expertise, risk, and – most of all – knowledge. In the last few years the studies dedicated to this new field have multiplied [25; 26; 47]. One example in this strand is Alter [1] who contributes three informal frameworks as a first attempt to define the fundamentals of service systems. Another effort is the *OASIS Reference Architecture Foundation for SOAs* [38]. Although the background is SOA, the specification argues that SOA-based systems are better thought of as ecosystems rather than stand-alone software products. Therefore, we classify this effort into the service system strand. It is directly related to our effort. However, the reference architecture foundation is not based on ontological analysis but takes the OASIS SOA-RM as its starting point by building on its vocabulary of important terms and concepts. Another effort considering the wider scope of the service system is the *Service Design Model* of Dhanesha et al. [11]. It is geared at a software engineering purpose and essentially comes in the form of UML. The model's scope takes into account the business organization, the customer, and the delivery organization during service design.

Our ontological foundations of service science represent a reference model with the scope being the whole service system which is common to the various strands described so far. It is based on and formalizes earlier ideas of Guarino and Ferrario [14]. Our approach is therefore mainly related to the efforts in the service system strand. Our approach differs in that it is explicitly built using the DOLCE foundational ontology. This means relating core classes and relations to proposed invariant categories of human cognition (which are reflected in the foundational ontology itself). This prompts the modeler to sharpen his notions with respect to the distinctions made in the foundational ontology. What is typically gained is an increased understanding of the modeled domain as well as a cleaner design.

3. BACKGROUND

3.1 Theory

Conceptual models typically condense multiple people's perceptions of a matter into a shared representation. Thereby, the models drawn upon always result in an abstract account of reality.

Conceptual models are usually graphical, i.e. semi-formal, representations [cf. also 24] and can be applied to static (e.g., data models) and dynamic (e.g., process models) states of affairs in some domain [55]. Generally they are used to structure and systematize problems and thereby used to omit irrelevant aspects of the surrounding scenario and help focus on the key problem at hand. Thus, a conceptual model is the representation of an application domain for the ends of a subject which is commonly based on a semi-formal language with a graphical representation [57].

According to Wand and Weber [55], conceptual modeling serves in particular to support communication between developers and users, to help analysts understand a domain, to provide input for the design process, and to document the original requirements for future reference. Usage in the early stages of information systems development is considered to be particularly beneficial, since the efforts for resolving mistakes made in this stage increase exponentially as time passes and subsequent project stages commence [cf. 30].

Evidently these different purposes require different modeling processes. If, for instance, conceptual models are intended to serve as an input for the design process, a formal and unambiguous grammar has to be used in order to map concepts precisely to implementation artifacts. Support for the communication process, however, can be achieved by less formal means, e.g. in tabular form [for other representation forms cf. e.g. 52].

We use UML class diagrams of the Technical Architecture Modeling (TAM) Standard [41] to visualize the model of the ontology. TAM represents a pragmatic combination of conceptual and formal modeling methods.

The starting point of the construction of a conceptual model is a result of perception and preexisting knowledge of an individual about phenomena in the application domain. This result of perception and cognition is represented as a mental model (or conceptualization) by the subject. Based on preexisting knowledge the mental model organizes perception into a coherent structure and establishes internal connections among them [12; 29; 31; 32]. The mental model is the basis for comprehension of the real world as well as its elements [48]. Its content is influenced by the intentions of the subject and the objectives of the conceptual modeling project. It reflects the pragmatic aspects of modeling and reduces as well as combines knowledge and perception accordingly.

These insights about a mental model lead to the following assumptions: A subject represents the results of perception and cognition as mental models. A mental model has a specific structure consisting of elements and relations. Also, the structure of a mental model is influenced by preexisting knowledge.

In a conceptual modeling process at least two different types of actors are involved. First, the model creators are the subjects who observe a material domain and explicate the conceptual model based on their insights. Second, the model users are the individuals who try to comprehend the conceptual model in order to learn about the material domain.

Based on this knowledge about the mental model and the corresponding roles, the conceptual modeling process [23; 32; 44] can be derived (cf. Figure 1):

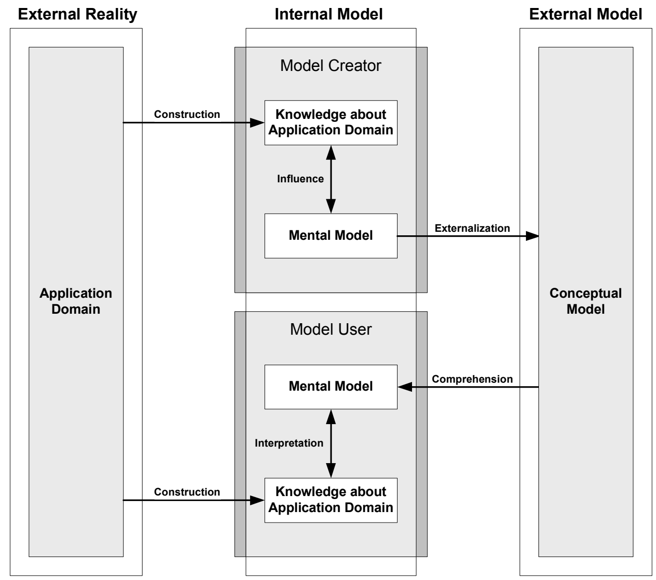

Figure 1. General Conceptual Modeling Process [cf. 22].

The external reality (the original) is perceived by the model creator and (re-)constructed in the form of a mental model [31]. This internal structure represents the intended comprehension of the conceptual model from its creator's perspective. The (re-)construction process is influenced by preexisting knowledge. Subsequently, the mental model is explicated as a conceptual model by the model creator [43]. Afterwards, the model user tries to comprehend the conceptual model in the form of an own mental model [17]. To accomplish that, knowledge about the application domain and the modeling method are required. The new mental model embodies the subjective comprehension of the conceptual model from the model user's perspective.

Thus, a conceptual model can only emerge and be interpreted successfully when the model creator and the model user share common knowledge. Only then the conceptual model can be properly encoded and decoded. If such a conceptual model is supported by an ontology (intended as a partial account of a conceptualization, i.e. a mental model), the alignment of the mental models of model creator and model user is greatly simplified. Aligning such domain-dependent mental models to general notions such as those specified in an upper-level ontology like DOLCE further contributes to make the semantics and the intended meaning of the terms used in the model more explicit, therefore reducing ambiguities and misunderstandings.

3.2 Research Approach

The origin of this research can be traced back to collaboration between the ISTC-CNR Laboratory of Applied Ontology and the office of social and housing policies of the Autonomous Province of Trento. The latter was seeking help from the former to conceptually “clean up” their catalogue of services.

During a series of interviews, Ferrario and Guarino found that people who have created or were using the catalogue had issues with different understandings of the same fundamental terms which co-existed in the catalog. Often people in the same business context were wrongly assuming to share the same conceptualization of what they were talking about. Thee most striking issue was the use of the term service itself: Some of them used the term *service* to refer to a series of actions, others to some kinds of actions, others to some capability to execute an action, while still others were called an office in a public administration a service, or the people working in it.

It was concluded that a foundational analysis was needed. First insights were presented in [14; 15]. The main feature of such an approach is that it adopts the *glass box view* [34] instead of the more traditional *black box view*. According to the latter, services are described as transfer functions from an input to an output state, with a strong focus on the external interface, as opposed to the internal view, which is kept separated. Hence the metaphor of the black box which does not allow others to understand how the service internally works.

If, on the one hand, this approach seems to work well from a technological perspective, on the other hand there is a well known gap between the business perspective on services and the IT perspective, which determines a difficulty of usage on the business stakeholder’s side. Business applications need not only specify what the service does, but also how the service is performed and when the various processes involved in a service occur (and this means reference to internal details). Still from another point of view, also contracts and service level agreements need to refer to internal and contextual details (thus how the service interacts with its outer environment). In other terms, one needs to be able to look inside the box and out of the box, i.e. one needs to have a glass box.

We chose a rather high level of abstraction as the main purpose of the model is to facilitate the understanding of (concrete) services and their facets and not their automated invocation and adaptation. When discussing examples, we found that the majority of differences in services can already be distinguished at this level of detail and drilling further into the model does not add sufficient surplus to justify the effort. It rather makes the discussion too complex for people not familiar with the model. Consequently, the general service model is supposed to be a baseline on which more concrete efforts such as USDL can build.

The general service model presented in this paper is a *design artifact* in the sense of the design science-based approach to IS research as described in Hevner et al. [20]. IS research accordingly is concerned with two design processes, i.e. to *build* purposeful artifacts to address heretofore unsolved problems, and to *evaluate* these artifacts with respect to the utility provided in solving those problems. Based on a thorough review of related work, we build a service meta model and validate its constructs through DOLCE and illustrate its usefulness and relevance by the means of examples.

In the following, we further embrace this view, with a special emphasis on the environment which the service belongs to, or, in other words, we take the socio-technical system into account which the service is a part of [2; 3].

4. GENERAL SERVICE MODEL

4.1 Overview of Service Activities

In this section we outline the central service activities and introduce the notions of service commitment, service process, and the service value exchange as central concepts of a general conceptual model of a service. We introduce in detail the core concepts of the service model and provide an alignment to the DOLCE foundational ontology.

Keeping in mind the wider perspective of socio-technical systems, we start by analyzing the internal structure of a *service system process*, consisting of different interconnected processes and events, resulting from complex interactions involving intentional agents and technological artifacts. Cf. Figure 2 for an overview. A *service system process* as such is composed by three main elements which are always present: the *service commitment*, the *service process*, and the *service value exchange*. Between the service commitment and both the service process and the service value exchange there is a relation of ontological dependence. The first dependence can be deduced by the informal definition given in [14]:

“A service commitment is an agent’s explicit commitment to guarantee the execution of some type of actions, on the occurrence of a certain triggering event, in the interest of another agent and upon prior agreement, according to a certain specification (service description) which constraints the way service actions will be performed (service process).”

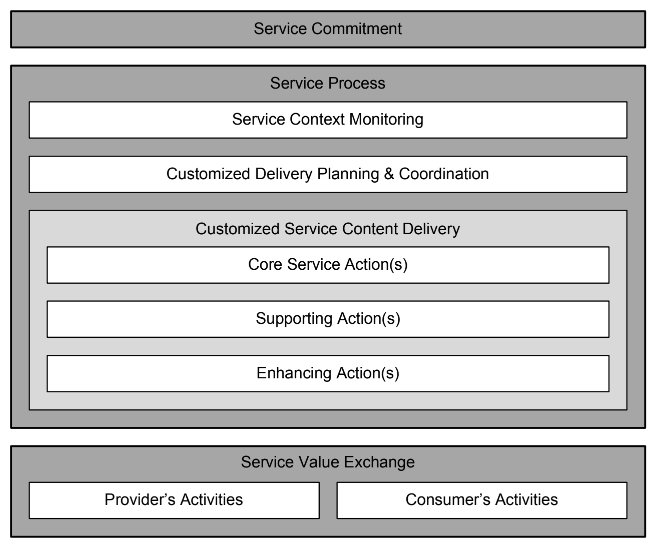

Figure 2. Activities in the Service System Process [cf. 14].

To better illustrate the concepts of the model, we introduce an example that we will use continuously throughout the paper. In order to reduce complexity, we use a service most people should be reasonably familiar with: a car wash. As with most service examples, there will be some cases where such an example is not the most appropriate. This is either because too simple or because it is out of focus. In those cases, we reinforce the explanation by using further alternative examples.

In the car wash example, we start with the event of the service commitment, when the owner of the car wash goes to the chamber of commerce to attend to all bureaucratic practices which are necessary to start the commercial activity. Among these practices, there will be some signed official declaration in which the main features of the service are described. It is such description the car wash owner commits to.

What actually happens in the service process is constrained by what is written in the service description which defines the actions that must and/ or can be executed in the service process and the range within which a certain parameter specifying the individual actions of the service process can vary.

The service value exchange is also ontologically dependent on the commitment, as the co-creation of value can in a sense be seen as the result of a more or less specific compliance of the service actions being performed during the service process and those defined in the service description that the provider has committed to.

The central part of the service process is given by the *customized service content delivery*, which is the actual event in which one executes what has been promised in the service commitment, it is composed by core service actions, that are those actions that, in a sense, characterize a service for what it is and must necessarily be exposed to the customer, and supporting and enhancing actions, that may or may not be visible.

The *service process* presupposes two other events, namely *context monitoring* and *customized delivery planning and coordination.* The former is necessary in order to detect whether the events triggering the execution of the service are occurring, the latter comprises all the organizational activities aimed at translating into practice for a specific customer the offer contained in the service description.

As mentioned above, the service process is composed of various sub-processes. Service context monitoring is hardly explainable through the example, as the event which usually triggers the car wash service is a request by the customer who shows up with his or her car at the car wash. But there are other cases in which this activity is much more important. Take for example a firefighting service; here the triggering event is the detection of a fire in the area of responsibility of that specific department. Such detection is the result of a monitoring activity of the area.

In customized delivery planning and coordination, a car wash offers a range of different possible implementations of the service, like washing only the outside of the car, or cleaning also the inside, using particular products, like specific shampoos or waxes, etc. In the customized delivery planning phase the customer and the provider at the car wash negotiate all these details. In more complex cases customer and provider may also negotiate other parameters such as the duration of the service (e.g. for a car repair) or what kind of resources necessary for the service will be paid for (e.g. new tires).

With respect to the service delivery as such, the core action here is washing the car; singling out supporting actions is more difficult in this example, as there are not many actions that are necessary to the service but are not explicitly mentioned as constituting the service. The procedure of taking out all the contents of the car in order to be able to clean the inside could be considered a supporting action. Similarly, a complementary coffee for the waiting consumer could be a supporting action. In other examples this becomes clearer. For a firefighting service, the action of driving to the place, where the fire is, is necessary to be able to extinguish the fire. But it does not fight the fire itself as a core action does. Enhancing actions, instead, are actions which are meant to augment the value of the service. Here we could think about an additional service that is connected but not strictly included in the service, like hand polishing the car.

The *service value exchange* is a complex process involving two agents, the service provider and the service customer who, through complementary activities, contribute to developing the value chain.

Note that the *service value exchange* is not a proper part of the service process, as the latter presupposes a commitment on the side of the service provider, while the *service value exchange* may actually start before the service provider has committed to have the service executed. The first phase of the *service value exchange* is the service awareness/ need awareness phase, which might be followed by the decision – on the provider's side – to begin building the service. In the next phase offer and demand meet, as the service provider advertises her service and the service customer searches for a suitable service; these are a bundling, presentation and pricing phase on the side of the service provider and a discovery and readiness to pay phase on the side of the customer. Subsequently, the service provider and service customer negotiate according to the respective expected benefits and bearable sacrifices. Then, sometimes before the service has been delivered, at other times right after the delivery, there is the payment phase. Finally, there is the follow up phase, in which positive or negative feedback should ideally guide the provider in ameliorating the service for the future. We leave a more detailed analysis of the service value exchange to the next Section.

4.2 Service Model

We now drill a level deeper into the nature of a service and its components. While Figure 2 gave a semi-formal overview of the activities that constitute a service, Figure 3 aims at characterizing in more detail the main concepts of our general service model.

Starting from the top, we see that the main element is the *service system process*, which can contain as part one or many *services* (and each service may be part of one or more service system processes) and complies with a *service system description*, namely an abstract representation of how the whole system should behave and how the service should interact with other elements of the environment. The description of this interaction can be given (possibly among other things) by a *price plan* (which is the value that can be ascribed to that service in the market or economic system in which the service occurs) and *legal constraints*, that are the consequence of the obvious fact that a service always operates in a legal system which can limit or regulate its range of applicability.

Participants to the service system process are the *service system context* (for instance the surrounding economic, legal, and social systems) and the actors, such as the service provider, service customer, service producer, and service consumer.

With respect to the car wash example, we already introduced the service commitment and the service process. Again, we will deal with the service value exchange later. The service system description can include details on maximum liabilities during the car wash and price plans for one or multiple visits or corporate plans. The service system context description includes all contextual information which is a given and not explicitly covered by the description. For a car wash this may include that you need

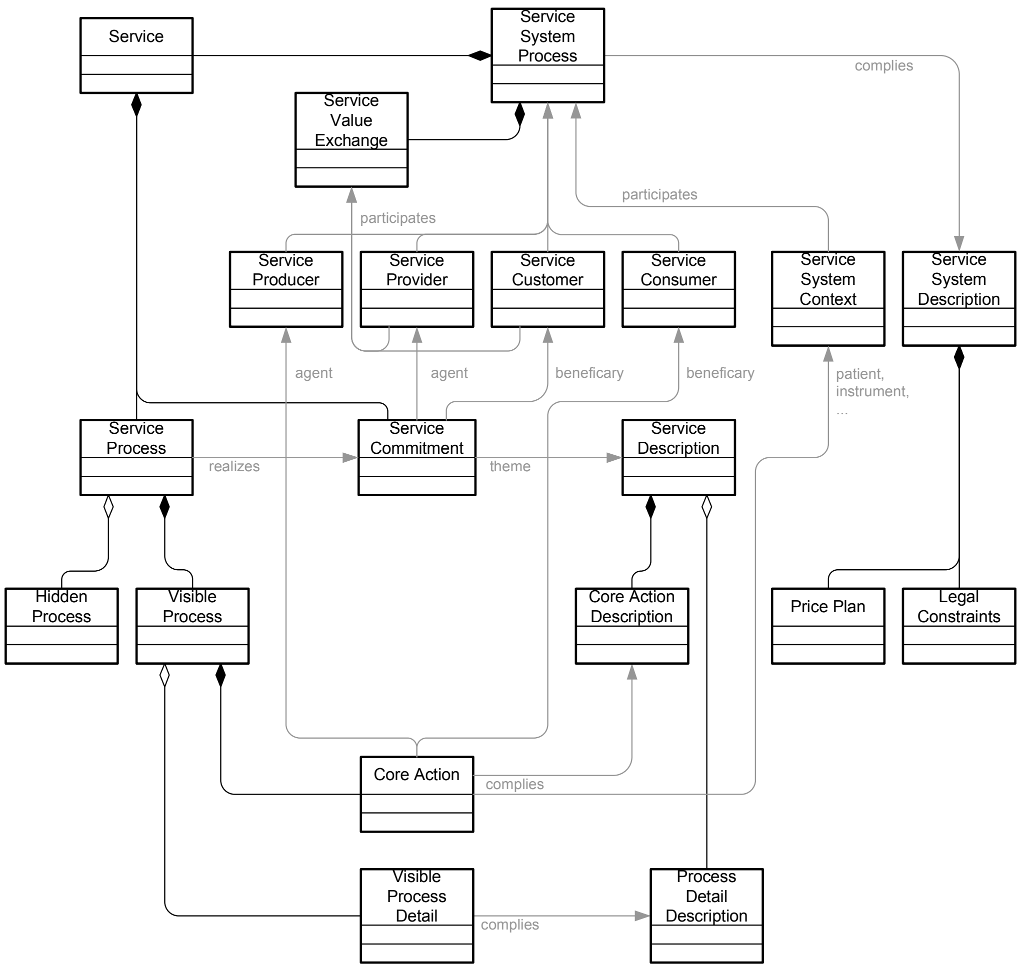

Figure 3. General Service Model.

to obtain a trade certificate before providing the service in a specific country or that you only take cleaning requests in the native language of the country you operate in.

Another participant to the service system process is, obviously, the service system itself. It has been left implicit and which can be defined as the mereological sum of all entities that participate in a service process (i.e. actors, but also resources and artifacts). There are more elaborate actor frameworks available but for sake of simplicity we refrain from expanding these entities.

The *service* has two essential parts, the service commitment and the service process. The latter should not be confused with the service system process (for instance, the way in which the price of a service changes belongs to the service system process and not to the service process).

The *service commitment* is connected through thematic relations (cf. also Section 4.3) to its components: service provider and customer, who participate in the commitment event as agent and beneficiary respectively, while the service description is the commitment's theme, in the sense that it is what the commitment is about, i.e. the provider commits to respect what is written in the description.

The *service process* realizes the commitment, i.e. it is the execution of the actions described in the service description, according to the constraints there stated and is composed by two parts: the *visible process* (mandatory) and the *hidden process* (optional); these two can be roughly identified with the front-end and the back-end processes. The visible process has some mandatory *core action* (those that in a sense define the service for what it is, i.e. the core action is what the service fundamentally does) and some optional *visible process detail*. These are usually enhancing or supporting actions which are performed in the back-end. The core action has to comply with the *core action description*, while the visible process detail has to comply with the *process detail description.* The core action description and process detail description are both part of the service description (though only the former is necessary). The hidden process does not have a correspondent in the description because it contains all those actions that are performed but not constrained by the description, i.e. the provider is free to perform such actions as he or she wishes since they are not ruled by the commitment.

Most of the above has already been exemplified in Section 4.1. As mentioned above, hidden process details are usually related to back-end activities. For example, the cleaning of car cleaning equipment after each fifth wash could be a hidden service. Hidden services are more common and also more notorious with smartphones due to their behavior to send data without the explicit consumers consent.

The agent who commits to the execution of a service process is called *service provider*, while the agent who actually executes the service is called *service producer*. These two may incidentally coincide, but this is not always the case. The *service customer* is the one who requires the service and hence also negotiates it and pays for it. Conversely, the agent who (actively or passively) participates to the service as the one whom the service is directed to is called *service consumer*. He may or may not coincide with the service customer. Service producer and service consumer both participate in the core action, the former as agent and the latter as beneficiary.

In the car wash example, the provider is the owner of the car wash, the producer is the person who washes the car and, if the driver of the car has borrowed it from someone else, the former is the customer, the one who pays for the service, while the latter, as ultimate beneficiary, is the consumer.

It is very important to conceptually distinguish the four roles, even though it can happen in practice that two or more of them coincide. In the car wash example, we can have cases in which the person who actually works in the car wash is also the owner (in this case provider and producer coincide) and, the most common case, when the driver of the car is also its owner. In this case, customer and consumer coincide. In other, more particular cases, we can have consumer and/ or customer coinciding with the producer, for instance when the car wash is an automatic one and the driver is the one who actually washes the car by driving through it.

Figure 4 shows the composition of the *service value exchange process* and how this interacts with other parts of the service system process.

Service value exchange is part of the service system process, not of the service itself. This choice is motivated by the fact that the components of the service value exchange, e.g. pricing, depend not only on elements which are intrinsic to the service, but also on things belonging to the service system context, such as laws that regulate the service or particular cultural and social traits that can make the result of a service more or less desirable.

The service value exchange is composed of five phases: *awareness*, *initiation*, *negotiation/ agreement*, *settlement*, and *after sales*. The only phase which has to be present in the service value exchange is negotiation/ agreement. Implicitly, the service provider and service customer are participants of all five phases. More specifically, four of these phases are composed by two complementary events, one in which the provider is the *agent* and the other in which the customer is the *agent*. During negotiation/ agreement, provider and customer, both act as agents. Furthermore, the figure details that awareness, initiation, and negotiation /agreement are all about the service description (which is what is exposed and negotiated between the parties). Settlement is relative to the visible process and the service result (which is what the customer ultimately pays for). The after sales process (both monitoring and evaluation) is about the compliance between service description and the actual service result and visible process. In order to render all these connections, we used the *theme* thematic relation.

The exchange usually starts with awareness, either of the service customers for a need they want to fulfill or the service providers in terms of an innovation they conceptualize and design. In the subsequent initiation, service providers make an offering of a service which can be discovered by service consumers. The exchange between the two parties is negotiated until an agreement is reached. During settlement the service provider invoices the service constomer who pays for the service. At this stage we exclude service delivery/ deployment as it may be considered as a service of its own to provide the service (similar to a customer buying a car wash ticket online and then buying a valet service to deliver his car to the car wash facility and back). The exchange continues after the settlement in an after sales process which allows the service provider to monitor the service use and the service consumer to evaluate the service.

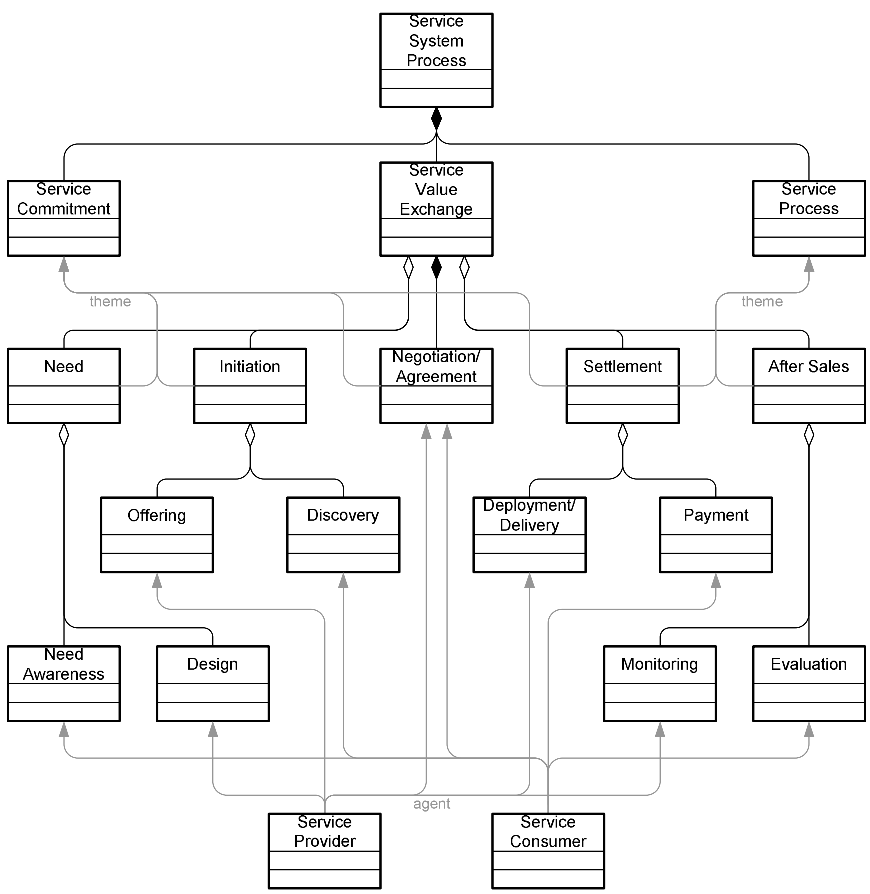

Figure 4. Service Value Exchange.

In the car wash example, we can think of the owner paying for some market study, in order to understand what the needs of the customers are that should drive the innovation that may be introduced in the service. This would be the awareness phase. For what concerns the initiation phase, we may think about the many ways in which the car wash can be advertised. In the negotiation/ agreement phase, the car driver and the owner discuss the price the former will pay for the service with some customized features which are also discussed and agreed. The driver will then pay, after the car has been washed and receives an invoice. The last phase is not really typical of this kind of service, but we can suppose that every customer/ consumer can be allowed to answer to a customer satisfaction questionnaire or post a feedback on a review website.

4.3 Ontological Foundation of the General Service Model

In contrast to philosophical ontology, Information system (IS) research has inherited and altered the idea of ontology. One can speak of informational ontologies, which are partial, domain specific, and committed to an epistemological constructivism [18; 45]. This plurality substantiates the introduction of different levels to structure different ontologies according to their specificity. Most classifications distinguish top-level or foundational, domain or task, and application ontologies [18]. Foundational ontologies are intimately related to the philosophical notion of ontology and are based on generic categories [8; 46; 54].

One of such foundational ontologies is DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) [28]. Its main characteristic – which may be inferred from its very name – is to be descriptive, rather than prescriptive. It tries to describe the surface structure of language and cognition: The focus is on making explicit already existing conceptualizations, rather than prescribing how a correct representation of a conceptualization should look like. It is an ontology of particulars, whose categories are taken from the mesoscopic level.

The choice of adopting DOLCE has been determined by the features of DOLCE mentioned above that make it especially appropriate for representing services according to a commonsensical perspective that could be congenial to all different stakeholders involved.

In DOLCE there is a primary distinction between endurants (roughly speaking objects that endure in time) and perdurants (things that occur in time, like events). For the sake of this paper, we just distinguish, among endurants, agentive physical objects (APO) and non agentive physical objects (NAPO), based on the fact that these objects display intentionality or not, and among perdurants, we distinguish states (stative perdurants), events and processes (both dynamic, but the latter having a behavior characterized by repetition).

In order to anchor the concepts just introduced, we refer to this foundational ontology. Figure 5 relates the uppermost elements of the general service model to the top categories taken from DOLCE.

Thus, service provider, service producer, service customer, and service consumer are all *agentive physical objects* (APO), while the service system context is a *non agentive physical object* (NAPO). The service commitment is a *state* (the state of being committed, to be kept distinct from the commitment act, which is an instantaneous event). The core action is an *event*, while the service system process, the service value exchange, and the service in its entirety including the service process are *processes*.

The model currently lacks an *is-a relation* for entities such as the service description, all its parts, the service system description and its parts. Intuitively, we could say that these are all descriptions and, thus, social entities. For the moment, we assume that these are *non agentive non physical objects*. Descriptions, though being in DOLCE, do not appear in its stable version. Thus, we have not included them in the Figure.

We used relations like *agent*, *beneficiary*, *theme* in the Figures above. In linguistics, these are called *thematic roles* or *thematic relations* [16; 21] and they are usually meant to express the relation between a certain element of a sentence and the action expressed by the main verb of the sentence.

Our choice is to employ thematic relations to describe the relations between the core action of a service and the other elements involved.

5. CONCLUSION

By elaborating on the current state-of-the-art and research issues in the area of service science and service description, we highlighted the necessity of a shared understanding, a shared conceptualiziation, of what a service is. We also provided evidence that there is preliminary research on this topic which needs to be extended to provide a sound basis for the engineering and brokering of services in particular and in order to serve as a foundation of the service science discipline in general.

We introduced a general service model based on the foundational ontology DOLCE, characterizing services in terms of endurants, perdurants, and their relationships. Using DOLCE on the one hand ensures that all entities used in the model correspond to a well-founded primitive and, thus, are meaningful. On the other hand it guarantees that all relevant ontological primitives have been taken into consideration and an ontological completeness of the model can be assumed.

The content of the model has been derived by considering related work and through research in large-scale research projects on service such as Theseus/ TEXO which involved face-to-face methodology workshops, conference call workshops, prototyping, and validation through small and medium enterprises as use case partners.

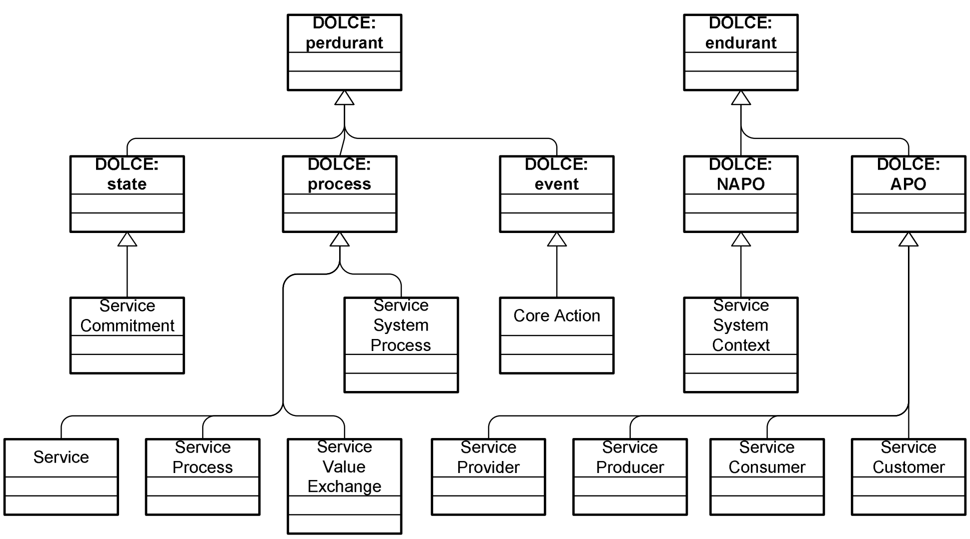

Figure 5. Relation of General Service Model and DOLCE.

In our understanding, a service is essentially composed of service processes whose core actions delivered by a service producer to a service consumer provide the capabilities that fulfill a service provider's commitment to a service customer. The service's description explicates these capabilities through the visible process details of the service process. We acknowledge that this part of it can be hidden in parts. Services compose a service system process which complies with legal and pricing constraints. It has a context which provides a frame for all performed actions.

The model is not yet stable. Next steps include dedicated work on special aspects such as legal aspects, service pricing or the description of hybrid services (i.e. product accompanying/ enabling services), the complete axiomatization of the model in the Web Ontology Language (OWL), and the closer alignment with a service description language such as USDL. If the model was serializable in an interchange format, the model can provide an actionable frame for communication purposes between service provider and service customer to describe business aspects as well as capabilities of services. The service description could be used in data exchange on services for discovery or service bundling.

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