Revealing Service Commitments in Service-Oriented Enterprise Architecture

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***Abstract*—In this paper we analyze the structuring principles underlying Service-oriented Enterprise Architecture (SoEA) in the light of a core reference ontology for services (UFO-S). The ontology provides a broad account for services and is centered on the service commitments/claims that are established by service participants throughout the service lifecycle. UFO-S is applied as theory to support the analysis of SoEA structuring techniques and thereby reveal social aspects inherent to service phenomena in SoEA (e.g., commitments/claims, and delegations) that remain underexplored due to the current prevailing *capability-based* SoEA view. From that, we advocate for a *commitment-based* SoEA view, which can be harmonized to the *capability-based SoEA* view in order to establish richer SoEA structuring principles. Implications of our analysis are discussed taking as basis widely adopted service-oriented approaches (SOA-RM by OASIS, ITIL, and ArchiMate).**

Keywords: Service-oriented enterprise architecture, service ontology, service commitments.

I. INTRODUCTION

Enterprise architectures, as blueprints, provide a holistic view of the enterprise, and capture essential aspects of business and IT [1]. With the increasing adoption of the service orientation paradigm in the last decade, the service notion has had increasing importance for enterprise architecture practices defining what has been called recently service-oriented enterprise architecture (SoEA) [2].

In a typical service-oriented enterprise architecture, the service concept acts both as a means to structure architectural elements within an architectural layer (e.g., relating a network of enterprises related through business services) as well as a means to link different layers, with "higher" architectural layers accessing the resources of the "lower" layers by means of services [1] (e.g., with IT services supporting business services [3]).

Despite the importance of services for SoEA, the notion of service is far from trivial and there is no consensus about what it exactly means [4], especially when this notion is used in and across different architectural layers. A number of service-oriented reference models, frameworks, and representation languages, such as the Reference Model for SOA (SOA-RM) by OASIS [5], ITIL [6], and ArchiMate [7], present particular perspectives of service (respectively, service as capability [8], service as mechanism to delivery value [6], and service as functionality [7]), all of which are focused on application of enterprise resources/capabilities.

Considering the variety of perspectives on the notion of service, we have proposed a reference ontology for services (termed UFO-S [9]) as a means to establish solid conceptual foundations for service science and service-oriented architecture. This *core reference* [10][11] ontology is built on the observation that service phenomena can only be fully explicated including the notion of service commitments. In this view, services are provided/consumed in a network of social relationships that, in fact, characterizes the complex notion of service [9]. As Ferrario and Guarino discuss in [12], service relations are based on the *social commitments and claims* established between service participants. These commitments/claims are established in service offer and service negotiation phases, and drive service delivery.

In addition to introducing this key aspect of service phenomena, UFO-S is able to harmonize the various perspectives on services in the literature [9]. Service commitments act in this core ontology as a "glue" between the various perspectives resulting ultimately in the use of enterprise resources to enact capabilities and fulfill service commitments during service delivery [9][13].

In this paper, we aim to show how this broad account of services that underpins UFO-S can clarify the structuring principles of SoEAs. We have observed that SoEAs have been influenced predominantly by the notion of service as a unit of functionality or capability, leading to what we call capability-based structuring of SoEA, here termed "capability-based SoEA view". We intend to present the limitations of this view and to show that, by introducing the notion of service commitments and claims one is able to reveal important business service relations that are not present in the capability-based SoEA view. Further, the notion we put forward is also applicable to IT services, being thus able to account for application and infrastructure as a service scenarios. The consequence of revealing service commitments throughout the SoEA leads to an additional structuring principle, here termed "commitment-based SoEA view". This view can be harmonized and combined with the prevailing capability-based SoEA view, offering a broader theory for SoEA structuring.

We believe that this richer SoEA view has implications for a number of SoEA-related academia and industrial initiatives, contributing to the structuring of SoEAs in general, and more specifically to Business-IT alignment efforts, to the integration of service management and EA, and the modeling/representation of SoEA.

This paper is organized as follows: section II presents an overview of what we call capability-based SoEA view; section III presents, in summary, ArchiMate as the modeling

language adopted for illustrating our analysis and discussion; section IV presents UFO-S (as a theoretical foundational for services based on service commitments and claims); section V presents the analysis of SoEA in the light of UFO-S; section VI discusses the implication of our ideas in current service-oriented approaches; and, finally, section VII presents the concluding remarks and indicates future work.

II. THE CAPABILITY-BASED SOEA VIEW

Layered enterprise architectures are an important way of organizing enterprise resources (e.g., business processes, human resources, software applications, and hardware devices) so that the resources located in "lower" layers support the operation of the resources in "higher" layers.

By counting on resources, enterprises can count on the capabilities inherent to them. According to [14], capabilities can be taken as intrinsic properties that inhere in individuals (e.g., people, enterprises, and devices). By controlling resources (e.g., a Database Management System - DBMS), an enterprise can count on the capabilities inherent to these resources (e.g., the "Data access" capability of the DBMS). In an enterprise architecture, resources (and their capabilities) can be combined within and through architectural layers in order to support business operation. For example, the "Data access" capability of a DBMS (IT resource) can used to build up a higher layer capability, e.g., a "Record Complaint" capability of an enterprise information system (a "Complaint system"). This capability of the "Complaint system" can then be used to support the business capability of "Handling Complaint".

Both in academic and industrial efforts, the service orientation paradigm has been taken as a vision of the world in which resources are cleanly partitioned and consistently represented in terms of services [15][16]. In SoEAs, services are often seen as a means of accessing the capabilities of Business and IT resources. In this work, we call this view the *capability-based SoEA* view.

This view can be found in important frameworks, such as ITIL [6], the Reference Model for SOA (SOA-RM) by OASIS [5], and ArchiMate [7]. In ITIL, the management of capabilities is an important aspect for guaranteeing the provision of IT services [6]. In SOA-RM, a service is defined as "a mechanism to enable access to one or more capabilities" [5]. In ArchiMate, the concept of service is characterized as "unit of functionality", which can be seen as realized/provided by application of enterprise resources (i.e., by manifestation of their capabilities) [7].

In fact, the wide applicability and acceptance of these frameworks show that the capability-based SoEA view is important and useful in SoEA structuring and practice. However, despite that, this view fails to account for social aspects inherent to service relations, such as service commitments and claims established between service participants (service providers and service customers), which we argue essential for a full account of service phenomena. Thus, by using a service commitment-based theoretical foundation capable to harmonize different perspectives of service (including "service as capability"), we believe it is also possible to harmonize the capability-based SoEA view with a *commitment-based SoEA* view towards enriching the understanding about service phenomena in SoEA.

III. SERVICE ORIENTATION IN ARCHIMATE

In this paper, we take ArchiMate as an archetypal framework embodying the capability-based SoEA view. ArchiMate is a widely-adopted technical standard (maintained by The Open Group) that was originally conceived with the *capability-based SoEA* view through its three architectural layers: Business, Application and Technology [7]. It includes a conceptual framework and also a modeling language for SoEA description [1], offering a "service" construct as a key modeling primitive.

In ArchiMate, the *business layer* deals with, among others, business processes, people (human resources), and organizational structure, aligning these elements to the enterprise strategy, and offering/hiring products/services to the external environment. The *application layer* supports the business layer with application services realized by software applications. The *technology layer*, in turn, supports the higher layers by providing infrastructure services (e.g., storage and communication services) realized by software and hardware (e.g., network devices, application servers, and DBMS). The example ArchiMate model in Figure 1 illustrates the layered structure of ArchiMate and how it can be used to representing a SoEA. In this example, a DBMS (a resource at the technology layer) realizes the "Data access" infrastructure service that is used by an enterprise information system at the application layer. This system, in turn, offers the "Record Complaint" application service, which is used in the context of the "Handling Complaint" business process by the "Attendant", which is the business role responsible for this process execution.

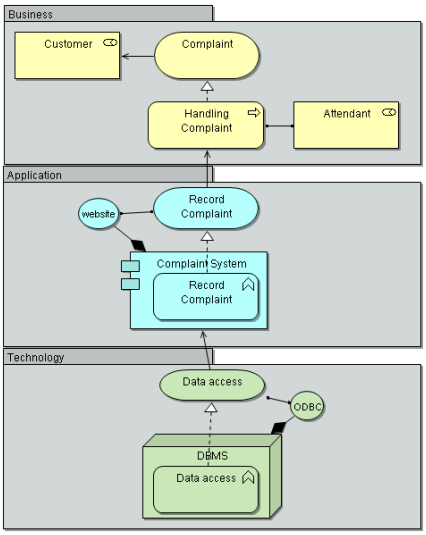

Figure 1. Exemplifying the usage of ArchiMate in a layered SoEA.

In ArchiMate, a *business service* is a unit of functionality realized by a business process (or other behavioral element) that fulfills a business need for a customer [7]. Similarly, an *application service* is a unit of functionality realized by an application component and exposed to the environment [7]. Finally, an *infrastructure service* is a unit of functionality realized by an infrastructure node to the environment [7]. Besides being used through enterprise layers, business, application, and infrastructure services can also be used internally at their respective layers.

IV. A Theoretical Foundation for Services Based on the Notion of Commitments

In this section, we present a brief description of UFO-S, a reference ontology for services based on the notion of service commitments and claims [9]. As a *reference ontology* [11], UFO-S is intended to assist humans in tasks of meaning negotiation and shared understanding. As such, UFO-S harmonizes a commitment based conceptualization with other perspectives for services found in the literature of "service science" and "service computing" (e.g., [5][17][18][19]) [9]. In this work, UFO-S is applied as a kind of "theory for analyzing" [20] service phenomena in SoEA.

As a *core ontology* [10], UFO-S is grounded in a foundational ontology (the Unified Foundational Ontology – UFO [21][22][23]), which offers a rich conceptualization about the notions of objects and agents, types, properties, relationships, events/processes, and social concepts (e.g., intention, commitments, claims, delegation, and dependence). The foundation offered by UFO has been successfully applied in previous works to evaluate, redesign, and ground ontologies, languages, and frameworks of several research areas, such as Software Engineering, Conceptual Modeling, and Enterprise Modeling (e.g., [24][23][25][26]).

UFO-S focuses on the three basic phases of the service life-cycle, namely [9]: (i) *service offer* (when a service is presented and made available to a target customer community), (ii) *service negotiation* (when providers and customers negotiate in order to establish an agreement), and (iii) *service delivery* (when actions are performed and resources/capabilities are applied to fulfill a service agreement).

Figure 2 presents a UFO-S model fragment regarding service offer. A service offer is an event (e.g., the registration of a service provider organization in a chamber of commerce, or a publication of a software service in a UDDI registry) that results in the establishment of a service offering, which mediates the social relations between the service provider and the target customer community. A service offering is composed of service offering commitments from the service provider towards the target customer community, and the corresponding service offering claims from the target community towards the service provider. Service offering commitments are meta-commitments (i.e., they are commitments to accept commitments), since they refer to commitments that can be established later in the negotiation phase. The content of the service offering commitments and claims may be described in service offering descriptions (e.g., folders, registration documents in a chamber of commerce, descriptions in software service registries, or service's portfolio in general).

Service provider is the role played by agents (e.g., *physical agents* such as persons, and *social agents* such as enterprises, departments, and organizational units [23]) when these agents commit themselves to a target customer community by a set of offering commitments. Target customer community is a collective that refers to the group of agents that constitute the community to which the service is being offered. Target customer is the role played by agents when they become members of the target customer community, and, as a consequence, have claims for the fulfillment of the commitments established by the agent playing the role of service provider. The service provider and target customer roles can be played by agents internal to the enterprise, e.g., departments, and organizational units, as well as by external agents, such as market partners.

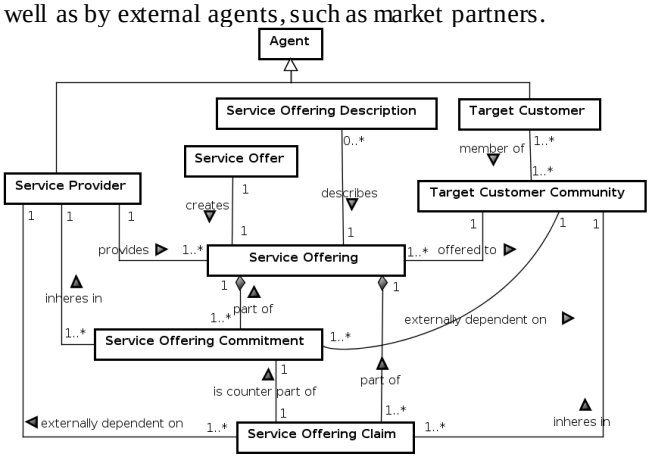

Figure 2. Service Offer.

Once a service is offered, service negotiation may occur. Figure 3 presents UFO-S model fragment of this phase. Service negotiation is an event involving a target customer and a service provider. If service negotiation succeeds, a service agreement is established, and the service provider starts to play the role of hired service provider, while the target customer starts to play the role of service customer.

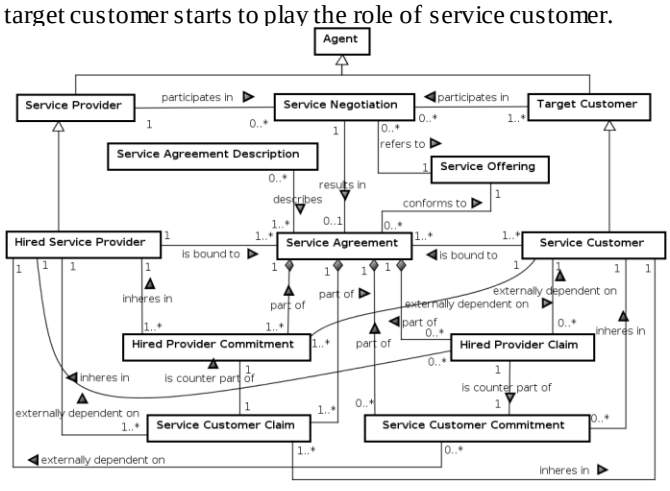

Figure 3. Service Negotiation.

A service agreement mediates the social relations between service customer and hired service provider, being composed of commitments and claims. Service agreements involve not only commitments from the hired service provider towards the service customer, but may also involve commitments from the service customer towards the hired service provider (e.g., the commitment to pay). Hired provider commitments and claims are properties that inhere in a hired service provider and are externally dependent on a service customer. Service customer commitments and claims are properties that inhere in a service customer and are externally dependent on a hired service provider. The content of commitments/claims of a service agreement may be described in a service agreement description (e.g., contracts).

When established a service agreement, the service customer delegates a goal/plan to the hired service provider. Depending on the business service model, this delegation may be open or closed. In an open delegation, the hired service provider is free to determine how to act and apply resources/capabilities for fulfilling the commitments. On the other hand, in a closed delegation, the hired provider commits to execute a pre-defined plan that specifies how the hired provider must act. A delegation in a service relation may be followed by further delegations, too common in supply chains and economic networks.

Figure 4 presents UFO-S model fragment regarding service delivery. Service delivery is an event composed by actions performed only by the hired service provider (hired provider actions), actions performed only by the service customer (customer actions), and/or actions performed by both in an interaction (hired provider-customer interaction). Thus, service delivery concerns the execution of actions aiming at fulfilling the commitments established in the service agreement. Depending on the business service model, other agents can also perform actions. For instance, the service provider can delegate some actions to a third-party (e.g., actions performed by human resources, or actions performed by third-business partners). These actions are also part of the service delivery process, but they are not explicitly represented in Figure 4.

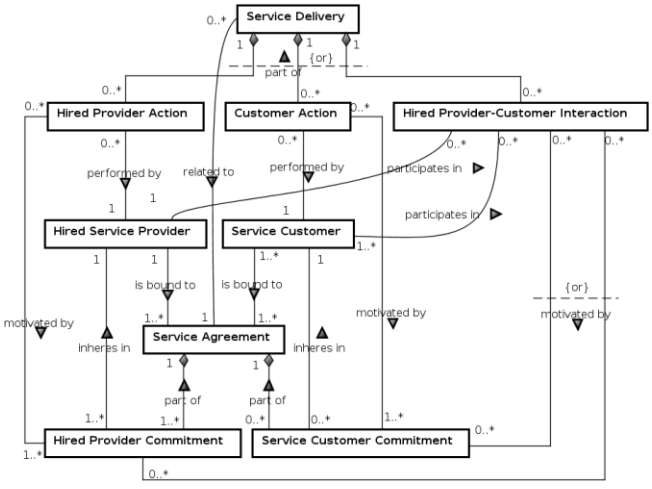

Figure 4. Service Delivery.

Concerning application of resources (or manifestation of their capabilities) in service provision, we can say that in service offer and negotiation phases, service provider and service customer are mutually committed to apply their resources (and their capabilities) for fulfilling the established service commitments. Thus, in service delivery phase, those resources (and capabilities) are used (manifested) as agreed.

Finally, an important statement of this theoretical foundation is the fact that service relation is inevitably a social phenomenon between intentional agents. Thus, only intentional agents can play the roles of service provider and service customer, since only this kind of agent can be committed to other agents. As a result, enterprise resources such as applications and infrastructure nodes do not themselves play the role of service providers and customers. Instead, service provider and service customers (agents) employ resources as a means to fulfill their commitments. Resources are thus used (their capabilities are manifested) as a means for providing services. As a consequence, mere application of resources (or manifestation of capabilities) is not enough to characterize a service relation. We will show in section V that this observation is key to revealing service commitments that are hidden in SoEAs and to harmonize the capability-based and the commitment-based view.

V. Analysis of SoEA in the Light of Service Commitments and Claims

In this section we analyze a number of service provisions in SoEAs in the light of UFO-S. For supporting our analysis, we use a hypothetical scenario of online book selling, which is modeled in ArchiMate as shown in Figure 6.

The analysis intends to show that the distinctions supported by a richer service commitment-based foundation (harmonized to the notion of resource/capability) allow us to reveal nuances in the capability-based SoEA view that, at first glance, remain hidden due to the emphasis on resources/capabilities in SoEA. Thus, a number of questions is used to guide our analysis, e.g.: (i) "who is responsible to honor SLAs (i.e., who is committed in service provisioning)?", (ii) "what are the service commitments/claims that drive the actions towards applying resources/capabilities for provisioning services?", and (iii) "what guarantees the establishment of a network of resources/capabilities (at different enterprise layers and from different business partners) for provisioning service?".

In the proposed scenario, the @Books Inc. bookstore sells books through the Internet. The bookstore provides two business services for its market customers: "Make purchase order" and "Monitor purchase order". Both services are completely automated by the "@Books' ERP" and can be accessed through a website. The "Monitor purchase order" offers the customer the facility of having online information about purchase orders made previously (including shipping information). Besides these services, the bookstore offers a "Complaint" business service. The market customers can have access to this service through phone calls (24h). In order to realize this service, the bookstore defines the "Handling complaint" business process that is conducted by people (human resources) playing the "Attendant" business

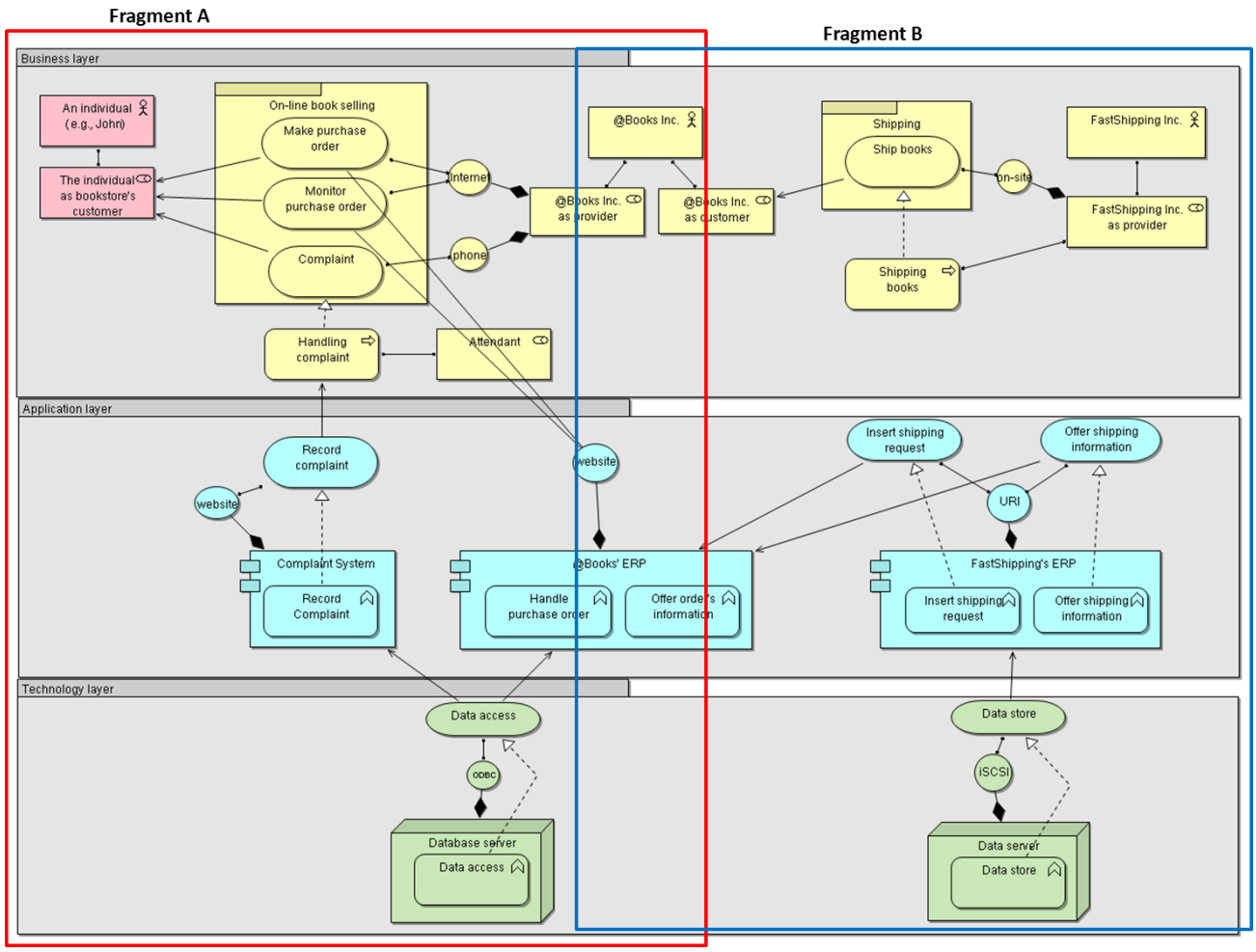

Figure 5. Online book selling scenario.

role. The attendants, along this business process, can use the "Record complaint" application service realized by the "Complaint system". Both, the ERP and the "Complaint system" use the "Data access" infrastructure service realized by the bookstore's database server.

For delivering the purchase orders, the bookstore has entered in a service relation with FastShipping Inc. (a company specialized in delivering goods). In this service relation, FastShipping also provides the "Insert shipping request" and the "Offer shipping information" application services to the bookstore. These application services are realized by the "FastShipping's ERP", and are available through RESTful technology. This ERP uses the "Data store" infrastructure service realized by the "Data server". By means of these application services, the ERPs of these two companies can be integrated and exchange information. Due to the service relation with FastShipping, the bookstore is capable to ship books ordered and also offer to its customers information about package tracking.

A. *Analysis of "intra-enterprise services provisioning"*

Consider the fragment A in the left-hand side portion of Figure 6. By means of this fragment we can analyze service provisioning internal to the same enterprise (through enterprise layers).

At the Technology layer, we have the "Data access" infrastructure service. We can say that, by owning the "Database server" (as an IT resource), the bookstore can count on the "Data access" capability. This capability, represented by an *infrastructure function* element in ArchiMate, is put internally available to the enterprise by means of that infrastructure service. This service, in turn, is used for supporting the operation of the "Complaint system" and the "@Books' ERP". The capabilities of the "Complaint system" can be accessed by an application service in a website available in the intranet, whereas capabilities of the ERP are available by direct access to this system through a website in the Internet. Thus, resources (and their capabilities) at the IT layers (Application and Technology) are used by resources at the Business layer for supporting business operations.

Since, in terms of UFO-S, service relations are only established between intentional agents, we can say that it is not the "Database server", or even the "@Books' ERP" (as IT resources), that "provide" these IT services (application and infrastructure services). In terms of UFO-S, the

resources (or the manifestation of their capabilities) are used (as agreed between service participants) as a means for delivering (Business or IT) services. This notion of service leads us to reveal the (intentional) agents involved in service relations, in such a way that we understand service provisions not only as mere application of resources/capabilities, but as a wide and organizational view that also considers the commitments between organizational actors towards guaranteeing the agreed application of resources/capabilities. Thus, in this fragment, there should be an IT department (or other organization actor not represented in the model) that would be committed to provide (by means of application of IT resources/capabilities) the aforementioned IT services. Note that not only the service provider is not identified explicitly, but also the service customers (which could be the, e.g., a marketing department, or even, the bookstore as a whole).

Revealing the actors that provide the "Record complaint" service allows us to consider not only application service provisioning from an internal point of view (i.e., an internal IT department establishing a service relation with the enterprise or with other departments), but also from an external point of view. In this latter case, the enterprise becomes a customer of another enterprise offering an IT solution of processing complaints (in a software-as-a-service business model). There would thus be a number of service commitments and claims between business partners that would drive the application of all resources/capabilities (from IT to Business resources/capabilities) necessary to provide this service. Emphasizing only the capability-based view hides the actors playing the roles of service customer and service provider, showing only the resources employed in service delivery. This prevents us from distinguishing the cases in which a piece of software is employed under no service management practice from those cases in which software is part of a genuine software-as-a-service model (either provided by internal or external actors).

In contrast to the capability-based view, the commitment-based view transcends the application of a resource's capability. For example, the "Record complaint" application service should not be thought of as being provided by the "Complaint system" because there are number of other capabilities that are required for providing this service (e.g., electricity, and security aspects) but that are not guaranteed by the "Complaint system" (as an IT resource). It is necessary, therefore, the "presence" of an intentional agent (e.g., the IT department) committed to guarantee the operation of the "Complaint system" and of all other resources/capabilities necessary for the provision of this application service.

As the commitment-based view emphasizes the opportunities for delegation, it can also be seen as a means to deal with the complexity of an organization's goals. In our example, the bookstore is committed to its target customers to sell books through the Internet. If the bookstore is acting honestly, this social commitment will be internalized into a goal ("to fulfill the established commitments towards its customers"). This general goal could be addressed by a number of strategies, some of which may involve the delegation of specific goals to internal organizational actors through service relations (e.g., such as those related "to guarantee provision of IT services" which can be delegated to the IT department.) As a consequence, the IT department will act (e.g., applying the IT resources and capabilities under its responsibility) towards creating means for fulfilling its commitments and, ultimately, contribute for achieving the overarching organizational goals. In this process, the IT department has the freedom to fulfill its commitments in different ways, as long as the commitments are fulfilled. This allows the enterprise architect to consider an alignment of the goals that arise from the need to fulfill commitments with other goals the actor intends to pursue (e.g., cost reduction in the IT department.) This analysis reveals a "separation of concerns" established by means of delegations in service relations. By delegating a goal/plan the customer can deals with the service provisioning at a high level abstraction (focusing on service commitments fulfillment perspective) and let other more specific aspects (e.g., usage/maintenance of resources/capabilities) under provider's responsibility. This contributes for the design of SoEA in a true modular fashion, including the alignment of goals of the various organizational actors as well as trade-off analysis.

Finally, there may be a number of service relation arrangements in a service-oriented enterprise. Here, we discussed some of them in order to show how social aspects (mainly based on service commitments/claims, delegation, and goals/intentions) can be useful for better understanding SoEA. The organizational structure and the autonomy of the departments and organizational units have direct influence on it. Despite these various possible arrangements, we believe that, beyond providing access to resources/capabilities by means of services, it is also important to analyze the relations between the intentional agents responsible for providing the services (service providers) and the beneficiary agents (service customers). Thus, it is possible to go from a mere application of resources/capabilities towards a more complete organizational view, in which organizational actors act as participants in service relations for fulfilling service commitments and achieving organizational goals.

B. Analysis of "inter-enterprise service provisioning"

We now analyze fragment B in the right-hand side portion of Figure 6. This fragment offers support for discussing service provisioning between enterprises.

Consider, initially, the "Offer shipping information" application service, which is realized by the "FastShipping's ERP" application. By using this service, the "@Books' ERP" application can have access to the information about the books' shipping status and thereby "Offer order's information". In terms of UFO-S, we can say that there is a set of mutual service commitments between the bookstore and the FastShipping that characterizes the service relation between these two enterprises. Through this service relation, the bookstore delegates to FastShipping the task of shipping books and, therefore, can count with the application of FastShipping's resources/capabilities which are necessary for this task. In this context, we can say that besides all service

commitments regarding the tasks involved in transporting a purchase orders to a customer's address, one of these service commitments concerns providing online information about tracking status of each package shipped. Thus, we can say that there is a service commitment established at business level that states that FastShipping is responsible for providing the "Offer shipping information" application service at application level. The provision of this application service, in turn, is characterized by a number of other service commitments concerning to technical aspects, such as communication protocol to be used, input and output parameters required, response time, etc.

This analysis, therefore, shows a relation between the application of IT resources/capabilities (besides other kinds of resources/capabilities) from one enterprise in benefit to another due to service commitments established between them at business level. Thus, the service commitments that guarantees (at a certain level) the provision of the "Offer shipping information" application service (and consequent application of the resources/capabilities) is one of the service commitments established in the context of the service relation between the bookstore and the FastShipping. This network of Business- and IT-layer resources/capabilities of different enterprises established and driven by a parallel network of mutual service commitments between these enterprises for delivering service is not evident or even clearly discussed in various service-oriented frameworks. ArchiMate, e.g., lacks a clear way to represent these aspects.

In addition to the "Offer shipping information" application service, the "Insert shipping request" service is also part of the commitments of FastShipping towards @Books. This service is used by the "@Books' ERP" to insert, in the "FastShipping's ERP", a request of a new purchase order shipping. In other words, when a purchase order is made, this application service is a way the bookstore has to request a new purchase order shipping for the FastShipping. We can analyze the use of the "Insert shipping request" application service taking as basis the dynamics of the service commitments and claims in the service life-cycle phases (service offer, service negotiation/agreement and service delivery). For that, consider that the bookstore and the FastShipping have established a business service model in which there is a permanent agreement regarding the service of shipping books. By this permanent service agreement, a simple shipping request (through the use of the "Insert shipping request" application service) is enough for triggering the "Shipping books" process, since all service provisioning terms (e.g., costs, delivery data, and transportation availability) where already agreed. In this case, therefore, the call to this application service acts as just an event that will trigger other service delivery actions (encompassing the execution of the actions and the application of resources/capabilities necessary for it).

As we can see, the service relation between the bookstore and the FastShipping encompasses a number of enterprise resources/capabilities of both enterprises (e.g., money, human resources, transport infrastructure, and information systems). The application of these resources/capabilities is guaranteed (at a certain level) by the mutual service commitments established between these service participants. In this sense, the enterprises may have the necessity to integrate/combine their resources/capabilities as a way of fulfilling their commitments. Thus, we can say that, for fulfilling the mutual service commitments established between the bookstore and the FastShipping, they have integrated their ERPs (as a kind of inter-enterprise application integration initiative). This integration was established by means of a technological service solution (e.g., RESTful services). Thus, the "Offer shipping information" and "Insert shipping request" application services can be seen, in this scenario, as a service technological solution by means of what IT resources/capabilities (e.g., the ERPs of both enterprises) were integrated for fulfilling the service commitments established between these enterprises at the business level. Therefore, the way in which IT resources/capabilities are integrated/combined at IT layers and how these resources/capabilities interact (in software application integration initiatives, for example) can be regulated/driven by the service commitments established between the service business partners.

Finally, let us suppose that the FastShipping decides to outsource all infrastructure of data storage. As such, the provision of a data storage service will be hired as an infrastructure-as-a-service (IaaS) business model. From this outsourcing, we could say that the FastShipping will count on the resources/capabilities necessary for storing data of another company, the DataCompany Inc. So, the "FastShipping's ERP" will have access to the data storage infrastructure of the DataCompany by means of a "Data store" infrastructure service. At the business layer, the FastCompany participates in a service relation with the DataCompany for having the provision of the data storage service. By that, the FastCompany can count on the DataCompany's "Data server" (as an IT resource) for storing data processed by its ERP. In this service relation, therefore, the FastCompany (as service customer) and DataCompany (as service provider) establish a set of mutual service commitments and claims that concern to the application of resources/capabilities towards the provision of the data storage service. An important aspect is that the analysis of this service provision can not be limited to the application of the infrastructural resources/capabilities (e.g., data servers, and electricity), but also other kinds of resources/capabilities for the management of infrastructure as a service, such as those one at Application layer (e.g., software applications for device management) or at Business layer (e.g., human resources, and SLAs management business process). As we have advocated, the application of all these kinds of resources/capabilities is guaranteed (at a certain level) by the service commitments and claims established between service provider and service customers at business level. The capability-based view, however, lacks a wider perspective of service relations that unifies the application of Business-layer and IT-layer resources/capabilities by the establishment of service commitments and claims through enterprise layers and between business partners.

In conclusion, it is important to reveal that there is a network of service commitments established between service participants that act as a "glue" that leads to the application of the resources/capabilities of these service participants as a way of fulfilling their commitments. As an example, the bookstore has entered in a service relation (i.e., has established service commitments) with the FastShipping for being capable (or in other words, for counting on the resources/capabilities) to fulfill her service commitments towards its customers. This network of service commitments is based on the notion of delegation of the service provisioning from the service customers towards the service providers. In the service provisioning, resources/capabilities of both parties (customers and providers) are applied towards fulfilling their mutual commitments.

VI. IMPLICATIONS TO SERVICE-ORIENTED APPROACHES

In this section, we discuss the implications of the commitment-based view to three widely adopted service-oriented approaches: the Reference Model for SOA by OASIS (SOA-RM) [5], ITIL [6], and ArchiMate [7]. Since these approaches are predominantly based on the capability view, we believe they can be enriched with the commitment-based view underlying UFO-S.

With respect to the OASIS SOA-RM [5], its focus is on the application of IT resources/capabilities in the provision of services. In terms of SOA-RM, by means of services it is possible to access the capabilities [5], which are means to realize one or more real-world effects [5]. The access to capabilities is, in SOA-RM, governed by the concepts such as "policy" and "contract" [5]. However, although SOA-RM offers these concepts to drive the application/access to capabilities, we believe that this reference model can benefit from the notion of service commitments and claims, as a means for detailing and relating the content of "policies", "service descriptions", and "business contracts" along service life-cycle phases. Thus, the dynamics of service commitments and claims along the service life-cycle (from service offer, passing through service negotiation/agreement until service delivery) can enrich the understanding about the dynamics of the responsibilities (in terms of SOA-RM) of the service providers and service customers (as intentional agents) in tasks such as service registration/publication (e.g., in UDDI registries), service negotiation/agreement (manually or automatically), and service execution/usage (e.g., by function calls). The service commitments and claims established between service participants (target customer, service provider, service customer, and hired service provider) along all service life-cycle phases are related and drive, ultimately, the application of capabilities as way of fulfilling the commitments.

Regarding ArchiMate [7], it adopts the perspective of "service as unit of functionality" within and through its three enterprise layers (Business, Application, and Technology). This perspective offers an important but particular perspective of service, and should be complemented with the commitment-based perspective in order to account for services more completely. Consider, e.g., the insurance service that is provided by an insurance company towards its market customers. In the end of the insurance service contract, even if no accident had occurred and no action/functionality had been performed, the customer could say that the insurance service was successfully provided. In this case, the service is not characterized only by an action/activity/unit of functionality (or by all resources/capabilities applied in service delivery), but also by the service commitments (the promise) of the insurance company to act (and apply the necessary resources/capabilities) as agreed in case of any accident. This example can be extended to the provision of application and infrastructure services, in which the usage/manifestation of IT resources/capabilities is guaranteed (even if they are not applied) by means of service commitments established between service participants. In fact, the service perspective of "unit of functionality" adopted by ArchiMate is too focused on the capability-based SoEA view, and is not sufficiently expressive for representing the social aspects concerning the application of resources/capabilities in service delivery. Due to that, ArchiMate also lacks suitable modeling facilities (e.g., without ambiguity) for representing, e.g., the nuances of inter-layer service relations (e.g., between Business and Application layers) that regard the application of resources/capabilities of lower layers for supporting the higher ones. For example, consider the case in which there is an application service being realized by an application component (e.g., a software system) and used by a business process. In ArchiMate, it is not possible to properly represent who is the service provider (the intentional agent) committed to the provision of this service, as the resources themselves are considered as service providers (through the assignment relation). We believe that these and other limitations could be minimized if the notion of service commitments and claims (and all the related aspects, e.g., delegation) were harmonized to the current capability-based view as a way of addressing semantic limitations and increasing the modeling language expressiveness. In fact, by means of ontological analysis of service modeling fragments at ArchiMate's Business layer (taking as basis UFO-S) [27], we have shown limitations of the language with respect to semantic clarity and expressiveness of business service relations. Recommendations for service modeling at the IT layers (Application and Technology) are being developed and should address all the scenarios for application as a service and infrastructure as a service that are discussed in this paper.

Finally, another important initiative that supports service orientation is ITIL (IT Infrastructure Library) [6]. ITIL provides a framework of best practice guidance for IT Service Management (ITSM). In ITIL, service management concerns organizational capabilities (e.g., process, functions, and roles) for providing value to customers in the

form of services [6]. Since the perspective of "management" is essential in ITIL, many of the aspects discussed here are directly applicable to ITIL (e.g., intentional agents as service providers and customers, service relations in a wider view encompassing Business- and IT-layer resources/capabilities, and IT services required by the service provider to deliver customer-facing services in a wide service relation). This work has the following implications to ITIL: (i) the ontological foundation (offered by UFO-S) can support ITSM practices with a broad conceptual basis, and (ii) by discussing these aspects/concepts in the light of SoEAs, we offer some basis for ITSM practices (embodied in ITIL) to be related to SoEA. If (Service-oriented)EA does not include the commitment-based view, then it would not be able to represent the important notions underlying ITSM.

VII. Concluding Remarks

In this paper, we have analyzed SoEAs in the light of UFO-S, a core reference ontology that characterizes service relations along service life-cycle using the notion of service commitments. In terms of "design science" research initiatives [28], UFO-S was applied as a theory to support the analysis of SoEA structuring techniques (that it sees as a kind of artifact, in a general sense).

This analysis enabled us to reveal and relate a number of aspects in SoEA that remained underexplored due to the prevailing capability-based SoEA view. Some of the revealed aspects can be summarized as follows: (i) the identification of the intentional agents (service providers and service customers) that are committed to act and apply their resources/capabilities for fulfilling their commitments towards delivering services as agreed; (ii) the characterization of a network of service commitments established between internal organizational agents as well as external business partners, which (at certain level) is responsible for guaranteeing the operation of a parallel network of enterprise resources/capabilities; (iii) the role of enterprise resources/capabilities (e.g., software applications, and hardware devices) and their integration to fulfill service commitments; and (iv) the separation of concerns established due to delegations of goals/plans in service relations within an enterprise (e.g., between departments, or between a department and the enterprise as a whole) and among different business partners. In this work, therefore, we have advocated that these revealed aspects contribute for the definition of a *commitment-based SoEA* view, which is not contrary to the prevailing *capability-based SoEA* view, but complementary. So, we advocate that these two views can be harmonized towards establishing richer SoEA structuring principles.

To the best of our knowledge, we are unaware of works that have discussed SoEA in the light of service commitments and claims as a way of evidencing social aspects inherent to SoEA (beyond the capability-based SoEA view). Despite that, implications of the commitment-based SoEA view were discussed taking as basis widely adopted service-oriented approaches (the Reference Model for SOA by OASIS, ITIL, and ArchiMate) in order to show the impacts of this view in SoEA-related initiatives, such as: SoEA structuring, service management, and SoEA modeling.

As future work, we intend to further investigate the characterization of this *commitment-based SoEA* view as well as in the harmonization to the *capability-based SoEA* view. As part of this effort, we plan to conduct a thorough analysis of the aforementioned service-oriented approaches with the aim of incorporating and/or make more evident this commitments-based view. Also, we intend to define a set of modeling patterns (encompassing intra- and inter-layer service relations) in ArchiMate for supporting modelers to clearly represent the aspects inherent to commitments-based view in SoEA. As mentioned in section VI, some of these modeling patterns are already defined [27], by means of which it is possible to represent *service offerings* (and types thereof) and *service agreements* at the Business layer. We intend to extend these to the Application and Infrastructure layers. Finally, we intend to conduct experiments and case studies in order to evaluate in which level the commitment-based SoEA view contributes for enriching the practice of modeling, definition, and management of service relations in SoEA.

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