From an Ontology of Service Contracts to Contract Modeling in Enterprise Architecture

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Abstract— **Service contracts bind parties legally, regulating their behavior in the scope of a (business) service relationship. Given that there are legal consequences attached to service contracts, understanding the elements of a contract is key to managing services in an enterprise. After all, provisions in a service contract establish obligations and rights for service providers and customers that must be respected in service delivery. The importance of service contracts to service provisioning in an enterprise has motivated us to investigate their representation in enterprise models. We have observed that approaches fall into two extremes of a spectrum. Some approaches, such as ArchiMate, offer an opaque "contract" construct, not revealing the rights and obligations in the scope of the governed service relationship. Other approaches, under the umbrella term "contract languages", are devoted exactly to the formal representation of the contents of contracts. Despite the applications of contract languages, they operate at a level of detail that does not match that of enterprise architecture models. In this paper, we explore the gap between these two extremes. We address the representation of service contract elements with a systematic approach: we first propose a well-founded service contract ontology, and then extend the ArchiMate language to reflect the elements of the service contract ontology. The applicability of the proposed extension is assessed in the representation of a real-world cloud service contract.**

Keywords: Legal contracts; service modeling; enterprise architecture; service contract ontology; ArchiMate.

I. INTRODUCTION

Services are provided/consumed in a network of social relationships that, in fact, characterizes the multiple aspects of this complex notion [1]. As Ferrario and Guarino discuss in [2], service relations are based on the *social commitments and claims* established between service participants throughout the service lifecycle. Service commitments/claims are established in service offer and service negotiation phases, and ultimately drive service delivery [3].

Given the key role of services in advanced economies, it is no surprise that services are subject to regulation and that service relationships in fact transcend a purely social realm into a legal realm. For example, in some legal systems, it is unlawful for an organization that has offered a service to refuse arbitrarily to provide the service to a particular customer in case no legitimate business reason is provided (in order to rule out arbitrary discrimination) [3]. Further,

interactions throughout the service lifecycle have important legal consequences. For example, legal execution of a debt may occur if a service customer fails to fulfill its payment commitments.

As a result of the importance of service relationships for service economies, service agreements are in their vast majority formalized into (written) contracts, which describe and stipulate how service relations are to be governed. Legal parties use contracts in order to guide their (mutual) actions in the scope of service relationships as well as to enact their legal consequences. Loosely speaking, we can say that a contract establishes legal commitments, duties, obligations, claims, rights, entitlements, prohibitions, exemptions, etc.

The importance of service contracts to service provisioning in an enterprise has motivated us to investigate their representation in enterprise models. We have observed that approaches fall into two extremes of a spectrum. Some approaches, such as ArchiMate, offer an opaque "contract" construct [4]. This means that, while ArchiMate acknowledges the benefit of identifying contracts for service-oriented architectures, it does not reveal the various legal positions that parties assume in the scope of the governed service relationship. Other approaches, under the umbrella term "contract languages" [5] [6], are devoted exactly to the formal representation of the contents of contracts. This means that they are able to reveal the ways in which parties ought to act in the scope of (service) contracts, which can be fruitful, e.g., in the analysis of business process compliance and in the verification of formal properties of contracts [7] [8].

Despite the applications of contract languages, they operate at a level of detail that does not match that of enterprise architecture models. In this paper, we explore the gap between these two extremes. We employ a systematic approach for the representation of service contract elements into Enterprise Architecture models. First, we propose a service contract ontology, which is rooted in both a legal core ontology (called UFO-L [9] [10]) and a core ontology of services (called UFO-S [3]).The service contract ontology is used as a basis to propose an extension of the ArchiMate Enterprise Architecture language and framework. The extension is integrated into the ArchiMate language "contract" construct, and the service relation patterns proposed in [11]. A notion of "contract element" is introduced to reveal the various legal positions of parties in the scope of the contract. The applicability of the extension is assessed in

the representation of real-world cloud service contracts.

The semantic foundations employed in our service contract ontology are aimed to ensure that the representation is adequate with respect to the underlying legal phenomena. UFO-L is based on Hohfeld's seminal theory of fundamental legal concepts and Alexy's relational theory of constitutional rights [12]. As a result, UFO-L accounts for a comprehensive set of related legal notions, including: *rights* and *duties*, *no-rights* and *permissions*, *powers* and *liabilities*, *disabilities* and *immunities*, as well as *liberties*. The relational nature of the account is particularly suited for the conceptualization of contracts, as opposed to the monadic and non-related nature of standard deontic logics that underlie many of the current approaches to the representation of contracts.

This paper is organized as follows: Section II presents the conceptual foundational for services that we adopt here (UFO-S); Section III presents conceptual foundations for legal relations, reviewing Hohfeld's and Alexy's notions as incorporated into UFO-L; Section IV presents the proposed service contract ontology founded on UFO-L and UFO-S; Section V presents an overview of ArchiMate service modeling at the business layer; Section VI discusses how we extend ArchiMate to incorporate service contract elements according to the service contract ontology; Section VII shows the application of the extension to represent a cloud service contract applying the extension introduced in Section VI; Section VIII discusses related work; and Section IX presents final considerations.

II. CONCEPTUAL FOUNDATION FOR SERVICES

The complex and multifaceted notion of service has led to a number of service characterizations [13] [14]. One of these is the notion of "service as commitment" [3]. Existing works in Service Science [15] and Service Computing [16] explicitly mention commitments, promises and/or obligations for characterizing the *service relation* established between service participants. The benefits of a characterization based on commitments have been discussed from the perspective of business [15] as well as IT [17]. In the context of Service-Oriented Architectures (SOA), Singh et al. [17] remark that commitments can be used for raising the low-level abstraction of existing SOAs, allowing to reduce the gap between the business and the IT perspectives. In their view, commitments capture business meaning, which is not directly represented in process-oriented approaches [17], since process-oriented approaches focus on the sequence of tasks in which resources and capabilities are used and applied. Aiming to harmonize different perspectives, a reference ontology called UFO-S was developed [1].

UFO-S is a core reference ontology for services based on the notion of social commitments. As a *reference ontology* [18], UFO-S is intended to assist humans in meaning negotiation and shared understanding. It is grounded in a foundational ontology (the Unified Foundational Ontology – UFO [19]), from which it reuses foundational notions of objects, types, object properties, object relations, events/processes, and further social concepts that specialize the more general notions and account for social reality. The social layer of UFO includes important notions of social

agents (e.g., enterprises), the objectives they pursue, the roles they play, the social relations they establish (commitments and corresponding claims), etc. Our choice of using UFO for building UFO-S can be justified by successful application of UFO 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., [20]). Moreover, a recent study [21] shows that UFO is perceived by modelers as particularly useful when analyzing notions pertaining to social and intentional aspects of reality.

UFO-S focuses on the three basic phases of the service life-cycle, namely [3]: (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 to fulfill a service agreement).

Fig. 1 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) 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, and artifacts in software service registries).
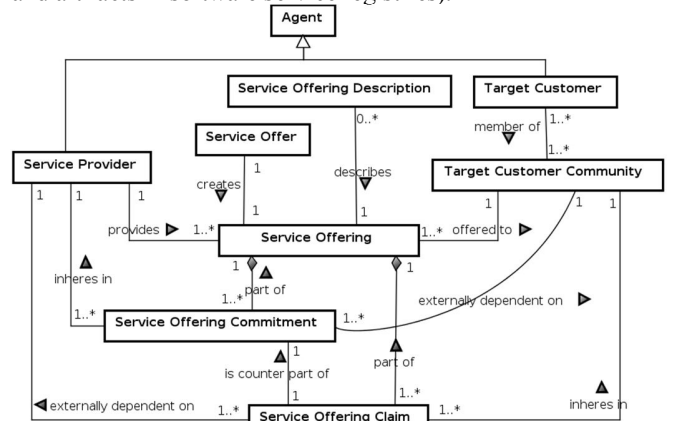

Fig. 1. Service Offering

Service provider is the role played by agents (e.g., physical agents such as persons, and social agents such as organizations [20]) 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, consequently, have claims for the fulfillment of the commitments established by the agent playing the role of service provider.

Once a service is offered, service negotiation may occur. Fig. 2 presents UFO-S model fragment of this phase. 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. A service agreement then 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 (objectified) 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 (such as a written contract).
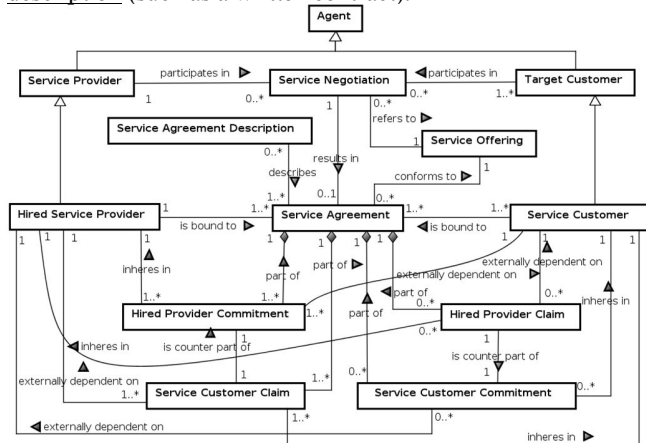

Fig. 2. Service Negotiation

When a service agreement is established, the service customer delegates a goal/plan achievement/execution to the hired service provider. Thus, the mutual service commitments/claims established in the service agreement will drive the service delivery. In other words, service delivery concerns the execution of actions aiming at fulfilling the commitments established in service agreements.

An important aspect of this approach is that service relations are inevitably a social phenomenon between intentional agents [3]. Only intentional agents play the roles of service provider and service customer, since only this kind of agent can establish commitments to other agents.

Another aspect is that service relations are specializations of *social relations*, which are, in turn, material relations. Like all material relations, service relations are grounded on a *relator* (a key notion in the UFO foundational ontology). A relator is an entity that is existentially dependent on at least two *individuals*, thus, mediating or binding them. A *relator* is

composed of at least two (possibly complex) *moments*. The notion of *moment* in UFO refers to what is sometimes termed a trope, an objectified property, a feature or a quality in the ontology literature. The term bears no relation to the notion of time and derives from the German term *momente* to mean *momentary feature or property* as used by the philosopher E. Husserl. For our purposes here, we can understand a moment as an objectified property that inheres (and, hence, is existentially dependent of) another individual called its bearer. The moments that compose relators are called *externally dependent moments* as they inhere in one individual while being also existentially dependent on another individual. For example, understood as a relator, the service agreement between John and Amazon, Inc. is composed by a bundle of relational moments (commitments and claims of John towards Amazon) that inhere in John but that are still dependent on Amazon as well as another bundle of moments (commitments and claims of Amazon towards John) that inhere in Amazon but that are existentially dependent on John. For an extensive discussion on the notion of relators and of moments, please refer to [19] [22].

A consequence of social relations is that some of them extrapolate the social realm and reach the legal dimension, becoming legally relevant. This is particularly true for service relations. This means that there are important aspects of service phenomena – the legal aspects – that are currently not addressed in UFO-S. We address these aspects here, reviewing the conceptual foundations for legal relations that underlie UFO-L in section III and applying these to UFO-S, which results in a service contract ontology presented in section IV.

III. CONCEPTUAL FOUNDATIONS FOR LEGAL RELATIONS

In a seminal work in the legal ontology literature, Hohfeld defined legal relation as a relation between subjects who are in certain legal positions [23]. He observed that key legal terms such as "right" were often misunderstood because of semantic overload. For instance, in the expression "right to smoke" the term right has the meaning of *permission*; in the expression "right to charge taxes" it takes on the meaning of *power*; in the expression "right to receives salary at the end of the month" it takes on the meaning of an *entitlement*. After an analysis of legal concepts, he identified eight fundamental legal concepts (*right*, *duty*, *no-right*, *privilege*, *power*, *liability*, *disability*, and *immunity*), and established relations between them. Table I shows these concepts, grouping them in pairs of correlative legal positions. Correlative positions are those with a counterpart in the same legal relation. For instance, the correlative of John's *duty* to pay his debt to Mary is Mary's *right* that John pay his debt. A right in this precise or 'narrow' sense is a legal position in which one may demand from another the performance of a certain conduct. Likewise, John's permission to use Mary's car correlates to Mary's no-right that John refrain from using her car.

CORRELATIVES			
Right	Privilege (Permission)	Power	Disability
Duty	No-Right	Liability	Immunity

The legal positions are also classified into two kinds: (i) those that arise from *norms of conduct*, namely: *right, duty, permission,* and *no-right*; and (ii) those that arise from *norms of power*, namely: *power, liability, disability,* and *immunity*. While norms of conduct have mainly a coordinative nature, norms of power presuppose a clear subordinate nature [12], and concern the creation, change and alteration of other legal positions.

In a legal perspective, a *service contract* is an arrangement between two or more parties whose purpose is produce juridical effects, i.e., to create, extinguish, modify, transfer or maintain legal positions. For instance, if a *service provider* A has a service contract to provide a service for *y* dollars to a *service customer* B, then *service provider* A has the *duty* to provide the service for *customer provider* B (who has the *right* to receive the service from A). Also, *service customer* B has the *duty* to pay *y* dollars to a *service provider* A (who has the *right* to receive *y dollars* for the service provided to B).

Alexy [12] proposed a system of legal positions embedding Hohfeldian legal positions in triadic legal relations and with the possibility to deny the legal relation's object (augmenting Hohfeld's theory). As a result, for each legal concept *right, duty, privilege,* and *no-right* to an action, there exists a concept of *right, duty, privilege,* and *no-right* to an *omission*. These legal positions are relevant in contracts because they define duties to negative actions (effectively prohibitions). For instance, in e-mail service contracts, the customer often has a duty to omit sending the same message indiscriminately to large numbers of recipients on the Internet (unsolicited e-mail or spam). The following categories are proposed by Alexy combining the legal positions of Hohfeld's theory with the new legal positions.

Right to Positive Action. Subject *a* has the right *R*, against subject *s,* to an act ϕ: R*as*(ϕ).

In this case, the addressee (*s*) has the *duty to perform* action ϕ. For instance, in a service contract with warranty, the *service customer* has the right that the *service provider* fixes the service in case of defect or failure.

Right to Negative Action. Subject *a* has the *right R,* against subject *s,* to an omission ϕ: R*as* ($\neg\phi$).

In this case, the addressee (*s*) has the *duty to omit* to perform action ϕ. For instance, a *service provider* must not disclose a customer's private information.

Permission to Act. Subject *a* has permission *P* towards subject *s* to perform action ϕ: P*as*(ϕ).

In this case, the addressee (*s*) has *no-right* to demand that the permission holder (*a*) omit action ϕ. For instance, in a messaging service, a *service customer* has the permission to send messages using the provider's infrastructure.

Permission to Omit. Subject *a* has permission *P* to refrain from acting (abstain to perform action ϕ) towards subject *s:* P*as*($\neg\phi$).

In a relational sense, the addressee (*s*) has *no-right* to demand that the permission holder (*a*) perform action ϕ. For instance, a *service customer* has the permission to abstain from paying contractual interest established by a *service provider* if it exceeds permitted by law in delayed payments.

Unprotected liberty. Subject *a* has liberty *L* in face of subject *s* to perform action ϕ or abstain from performing it: L*as*(ϕ).

The idea of liberty is related with an *alternative of action* as well with the fundamental legal concept of *permission*. It means that subject *a* is permitted to perform or to abstain from performing action ϕ. Conversely, subject *s* has no-right to demand that the liberty holder *a* perform or abstain from performing action ϕ. For instance, airline customers usually have the liberty to use in-seat entertainment.

Power. Subject *a* has the power *K* in face of subject *b* to create, change or extinguish a legal position X for subject *b* by means of institutional actions: K*ab*(*Xb*).

Power is created by a *competence norm*. The exercise of a power is an institutional action, which gives liberty and ability to act to a power holder. Since *power* has a converse position, it means that subject *b* is in a *subjection* position toward subject *a* (*subjection* is also called *liability*). For instance, often a *service provider* has the power to cancel the service agreement unilaterally in the case of contract violations.

Disability. A subject *a* has, in face of subject *b,* no power to create, change or extinguish a legal position X for subject *b* by means of institutional actions: ¬K*ab*(*Xb*).

The converse position of a disability is *immunity,* and the subject *b* is immune to changes in its legal position. For instance, often a *service provider* is immune to cancellation of a service agreement unilaterally in the cases of *force majeure*.

Based on these legal concepts, we have built a legal core ontology called UFO-L [9] [10]. This core ontology uses the *Unified Foundational Ontology* (UFO) [19] as ontological basis specializing ontological categories from UFO-A (endurants) and UFO-C (social aspects) (fig. 3). Thus, *Relator* (UFO-A) is specialized in *Social Relator* (UFO-C), that is, in turn, specialized in Legal Relator (UFO-L). There are two kinds of legal relators: Simple Legal Relator and Complex Legal Relator. A Simple Legal Relator is composed of a pair of legal positions (categorized in UFO-L as legal moments), such as: Right/Duty, NoRight/Permission, Power/Subjection, and Disability/Immunity. In contrast, a Complex Legal Relator is composed of other legal relators in general. For instance, Unprotected Liberty Relator is composed of NoRight to an Action–Permission to Omit Relator and NoRight to an Omission–Permission to Act Relator.

In turn, legal moments are related each other by a correlation association and are essential and inseparable parts of a legal relator [19]. For instance, the prohibition "Claire can not send billing messages via Amazon Email Service", means that Claire's legal position of duty to abstain herself from sending billing messages by email is intrinsically related to her and it is externally dependent on Amazon as well. Furthermore, Amazon has the right that Claire shall abstain herself from sending billing messages by Amazon Email
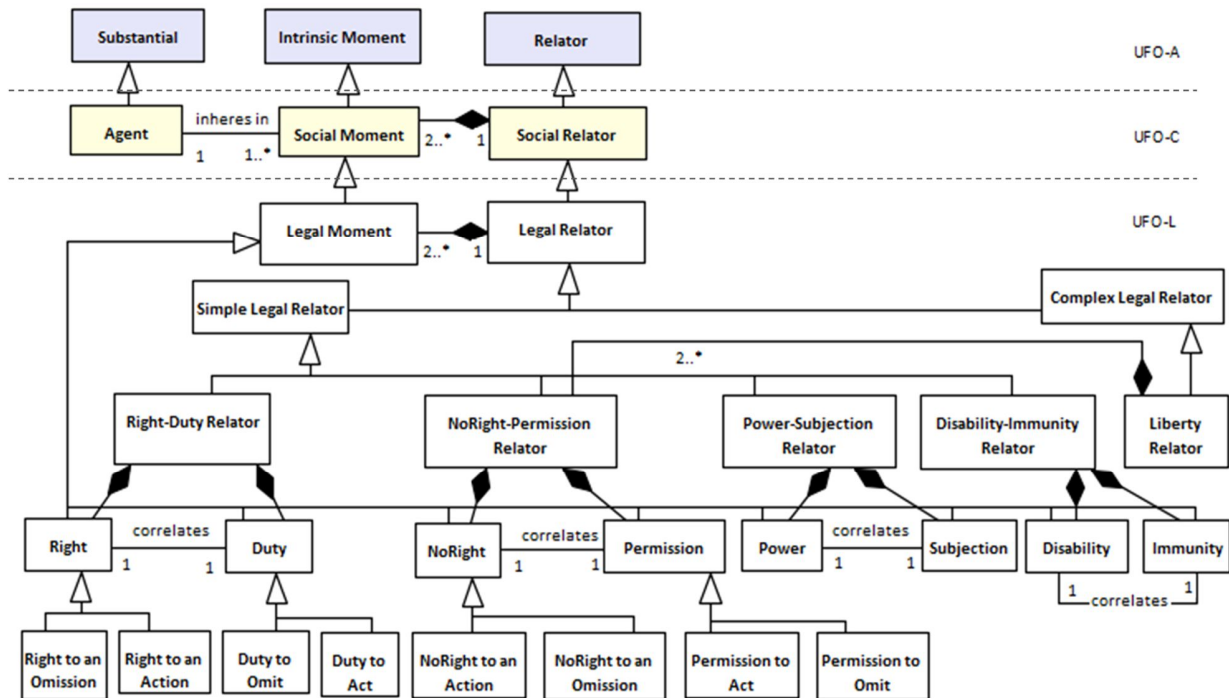
Fig. 3. Fragment of UFO-L

Service. A fragment of UFO-L is shown in Fig. 3 with the existing legal positions, the taxonomy of legal relators and its bindings with UFO-C and UFO-A.

Legal Moments are specialized in: Right, and its specializations: Right to an Action, Right to an Omission; Duty and its specializations: Duty to Act, Duty to Omit; NoRight and its specializations: NoRight to an Action, NoRight to an Omission; Permission and its specializations: Permission to Act, and Permission to Omit; Power, Subjection, Disability, and Immunity.

In this service context, UFO-L is used to represent existing legal elements in service relations from a relational perspective. In particular, the use of UFO-L to represent agents' legal positions in a service agreement allows us to detail further the contract and its elements.

IV. ONTOLOGY OF SERVICE CONTRACTS

By analyzing service phenomena as considered in [3], we realized that service relations also are relevant in the legal dimension. However, different dimensions suggest different requirements. From a legal perspective, by analyzing service contracts, for instance, it is relevant: 1) to understand and explain the "rules of the game" and therefore raise the awareness and compliance of these rules; 2) to explain the legal positions of each participant in a service relation and to clarify their roles, their actions and their responsibilities. The legal positions of UFO-L include not only those corresponding to commitments and claims from UFO-S (i.e., right and duty), but also other elements which had not been addressed earlier in UFO-S (no-right, permission, power, subjection, disability and immunity). Thus, in this section, we expand the reach of our service ontology by addressing a more

comprehensive set of ways in which parties may participate in service relations, reflecting a comprehensive legal theory. To respond to these demands, we built a service contract ontology based on concepts and relations from UFO-S (the part of the ontology in yellow) and UFO-L (the part of the ontology in white) as shown in Fig. 4. The connection of the UFO-S elements shown in Fig. 4 with the ontological categories of UFO is explicitly established in the original article [1].

Thus, Service Agreement is specialized into Legal Service Agreement. Since a legal service agreement has different kinds of service legal relations, with customers and service providers playing different roles, a legal service agreement can be understood as the composition of legal moments, which we call: Hired Service Provider Entitlement, Hired Service Provider Burden/Lack, Service Customer Entitlement, and Service Customer Burden/Lack). These specialize the 'social' notions of Hired Service Provider Claim, Hired Service Provider Commitment, Service Customer Claim and Service Customer Commitment of UFO-S.

In this service contract ontology, we separate legal positions in two kinds of legal moments: 1) Legal Entitlements (Right, Permission, Power, and Immunity); and 2) Legal Burdens/Lack (Duty, NoRight, Subjection, and Disability). Legal positions that imply some advantage (or entitlement) are grouped in the first set: Right to an Action, Right to an Omission, Permission, Power, and Immunity; legal positions that imply some legal burden or lack of entitlement are grouped in the second set: Duty to Act, Duty to Omit, NoRight, Subjection, and Disability.
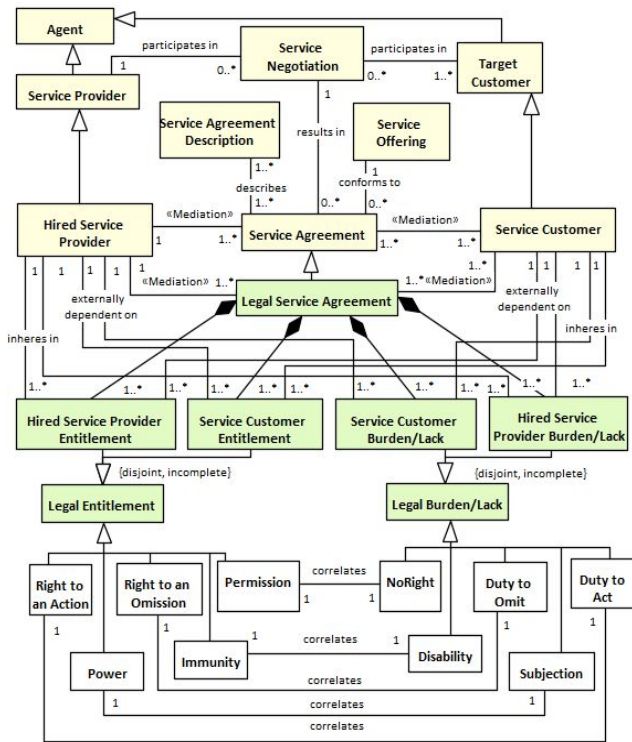
Fig. 4. Service Contract Ontology

V. An Overview of ArchiMate Service Modeling at The Business Layer

Since its inception, ArchiMate has included service-related elements in its *Business layer,* which describe the provision of business services to enterprise customers. This layer comprises structural, informational, and behavioral elements [4]. The *structural elements* refer to entities that make up the organization (e.g., business actors) and their relationships. The *informational elements* are related to the purpose of communication (e.g., products and contracts). The *behavioral elements* are used to characterize the dynamic aspects of an organization [4]. All these elements can be linked by means of relationships. Fig. 5 shows a fragment of ArchiMate's Business layer metamodel, focusing on the relations between business services and the structural and informational elements.
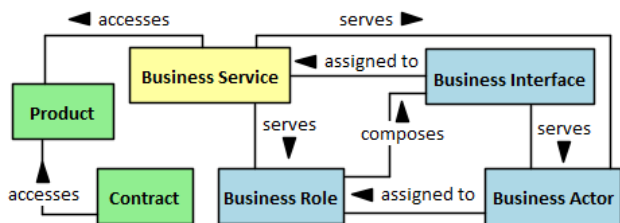
Fig. 5. ArchiMate's Business layer metamodel fragment.

In ArchiMate, a *service* is defined as "a unit of functionality that a system exposes to its environment, while hiding internal operations, which provides a certain value" [4]. A product is defined as "a coherent collection of services, accompanied by a contract/set of agreements, which is offered

as a whole to customers" [4]. A contract is "a formal or informal specification of agreement that specifies the rights and obligations associated with a product" [4]. The complete notation of ArchiMate used in this paper is found in [4].

In previous work [11] [24], some of us have identified that ArchiMate does not distinguish between the various service lifecycle phases. To address this shortcoming, three modeling patterns were proposed: a service offering type pattern, a service offering pattern, and a service agreement pattern. These modeling patterns were given real-world semantics based on UFO-S. The proposed modeling patterns use the existing service, product and contract modeling elements, as well as the association relationship [11]. Each pattern is composed by four groups of elements: (i) a product and related *services*, (ii) the *roles/actors* that provide the product/service, (iii) the *roles/actors* that consume the product/service, and (iv) the respective *contracts*. The *contracts* are in the center of each modeling pattern. The associations in which a contract is involved establish the semantics of each pattern. For instance, in a service agreement, the contract connects the (hired) provider actor with a particular customer actor. Fig. 6 presents an example with the service agreement pattern. The model illustrates a service agreement between "Mary" and "Easy TV, Inc.", which play, in this service agreement, the roles of service customer and hired service provider respectively. The terms of this agreement are described in the "Mary-Easy TV, Inc. Contract", which associates the two individuals involved.
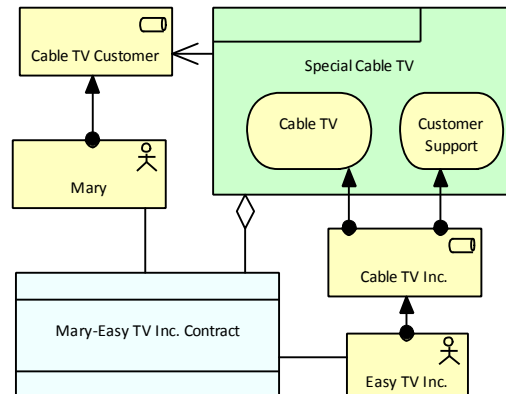

Fig. 6. An example of the service agreement modeling pattern [24].

Despite the usefulness of the contract element in service modeling, service elements revealing the various legal positions in the scope of a contract are not represented in ArchiMate. This motivates our extension which is discussed in section VI.

VI. Modeling Contract Elements in ArchiMate

Based on the legal positions in the service contract ontology and the basic symbols/colors used in traffic signs, we defined a set of symbols for service contract elements as shown in Tables II and III. Table II shows the concrete syntax for legal positions reflecting norms of conduct and Table III shows the concrete syntax for positions in power relations. These symbols decorate the current contract symbol, resulting in a symbol for each kind of legal position that can be represented.

TABLE II. CONCRETE SYNTAX OF CONDUCT RELATIONS

LEGAL POSITIONS	
Right	Duty to act
	Duty to omit (prohibition or duty-not)
NoRight	Permission (no-duty)
	Liberty

TABLE III. CONCRETE SYNTAX OF POWER RELATIONS

LEGAL POSITIONS	
Power	Subjection (Liability)
NoPower (Disability)	No-Subjection (Immunity)

Service contract elements are represented as parts of a contract (e.g., using nesting). Fig. 7 shows the case presented in Fig. 6 with a representation of the following legal relation: *Mary is prohibited to share her cable TV with a neighbor.* In this case, Mary's legal position is a <u>Duty to Omit</u> and Easy Inc.'s legal position is a <u>Right to an Omission</u>. Here, the position of Mary is emphasized, and the correlative position of Easy TV can be inferred. When used to related service contract elements, an *assignment* relationship represents *inherence*, and an *association* relationship represents *external dependence*; causal relationships (between causal clauses and sanctions) are represented by the *trigger* relationship. Note that we use the assignment relation to assign the legal position to Mary. Although a service contract element is strictly speaking a structural element and not a behavioral element, the use of this relation is analogous to that between actors and roles in standard ArchiMate. This is because, similar to role assignment, there are behavioral consequences of the assignment of contract elements.
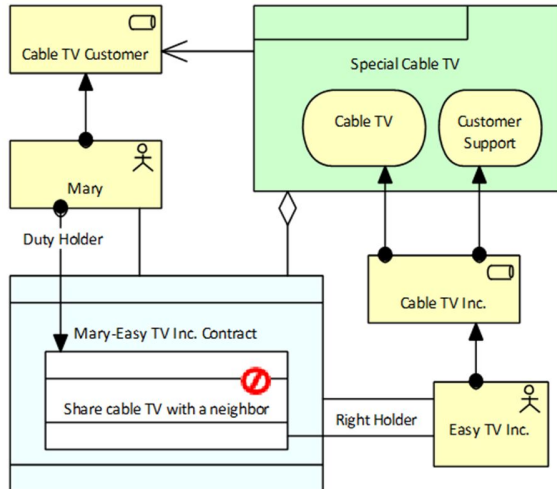

Fig. 7. An example of the service contract element modeling.

VII. MODELING CLOUD COMPUTING SERVICE CONTRACTS

In this section, we apply the proposed extension to ArchiMate to model the Amazon Web Services Agreements (AWS Agreements). AWS is a collection of cloud computing service provided by Amazon, Inc. We selected contracts related to two services: *Simple Notification Service (SNS)* and *Amazon CloudFront.* Specific legal provisions concerning each of the services are provided respectively in clauses 2 and 17 of the *AWS Service Terms* [25]. Further, both services are governed by the universal terms described in clause 1 of this contract. Moreover, the services are also governed by the *AWS Acceptable Use Police* and *AWS Customer Agreements* [25].

First, we designed a general diagram relating the various contracts with the products they govern (Fig. 8). This fragment is supported by ArchiMate with no extension. Second, we detailed each agreement element using the service contract elements described in Section VI. The resulting model was created by employing the following steps:
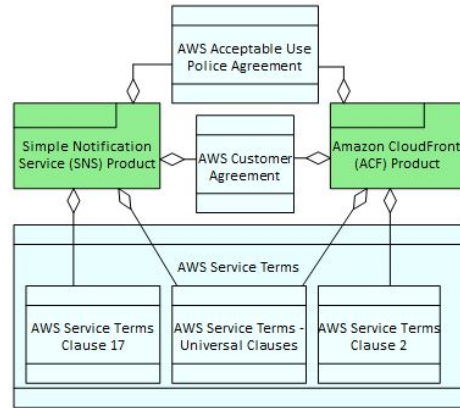

Fig. 8. AWS Services and its contractual objects.

STEP 1: Extract every existing legal relation from contractual clauses. For some clauses, more than one legal relation was extracted (Table IV).

TABLE IV. SOME CLAUSES OF AWS SERVICE TERMS

CLAUSES	LEGAL RELATION
17.1 You <u>may only use</u> Amazon SNS to send notifications to parties who have <u>agreed to receive notifications from you</u>.	Right-Duty to an Omission
17.2 We <u>may throttle or restrict</u> notifications if we determine<u>, in our sole discretion</u>, that your activity may be in violation of the AWS Acceptable Use Policy or the Agreement.	NoRight-Liberty
17.3 Your notifications sent through Amazon SNS may be blocked, delayed or prevented from being delivered by destination servers and other reasons outside of our control and <u>there is no warranty</u> that the service or content will be uninterrupted, secure or error free or that notifications will reach their intended destination (...) we may not be able to provide the service if a wireless carrier delivering SNS notifications by short messaging service (SMS) terminates or suspends their service. Your <u>payment obligations</u> <u>may continue regardless</u> of whether delivery of your notifications is prevented, delayed or blocked.	NoRight-Permission Right-Duty Disability-Immunity
17.4 You <u>may not use</u> Amazon SNS to send SMS messages that include Premium Content (...). You <u>must</u>	Right-Duty to an Omission

advise recipients receiving Amazon SNS notification by SMS that wireless carriers may charge the recipient to receive Amazon SNS notifications by SMS (...). You must obtain our prior written consent before using Amazon SNS to send SMS messages (...)	Right-Duty to an Action Power-Subjection Permission-NoRight

STEP 2: Identify which legal position is emphasized in the legal relation (Table V). In most cases, the emphasis in the text was preserved. In one case (clause 17.3), concerning payment obligations, we have opted to represent the right of Amazon to receive payment as this right is protected by an immunity.

TABLE V. FRAGMENT OF AWS SERVICE TERMS

Clauses	Legal Relation	Emphasized Legal Position
17.1 (Fig.9)	Right-Duty to an Omission	Duty to omit
17.2 (Fig.9)	NoRight-Liberty	Liberty
17.3 (Fig. 10)	NoRight-Permission Right-Duty Disability-Immunity	NoRight Right Immunity
17.4 (Fig. 11)	Right-Duty to an Omission Right-Duty to an Action Power-Subjection Permission-NoRight	Duty to omit Duty to act Power Permission

STEP 3: Design the corresponding *contract element* and include the corresponding visual construct of legal position emphasized in the relation (Figs. 9-11).
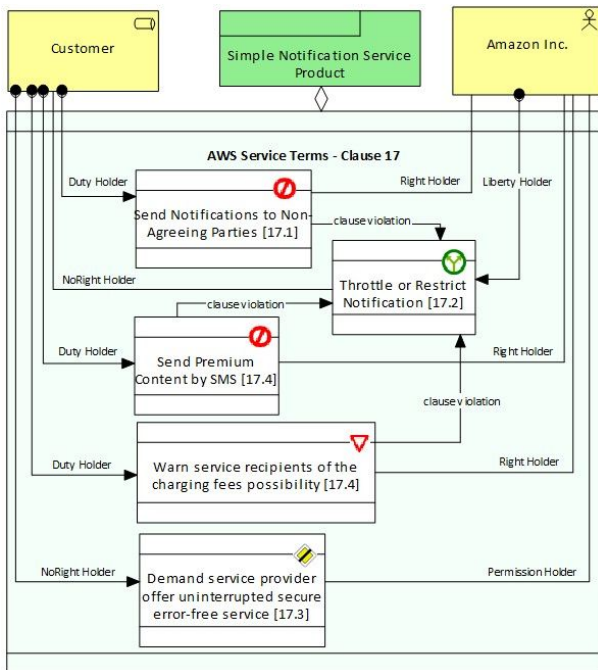

Fig. 9. Fragment of AWS Service Terms – Clause 17.

STEP 4: Verify which legal subject is the bearer of the most salient legal position and connect the holder with the contract element using an *assignment relationship*. The other subject is related to the contract element using a simple *association link*. Name each relationship with the corresponding UFO-L legal roles categories (Figs. 9-11).
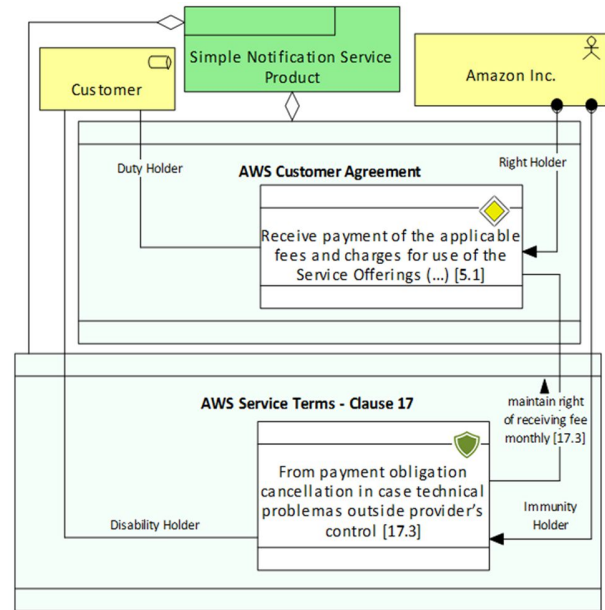

Fig. 10. Fragment of AWS Customer and AWS Service Terms

STEP 5: Represent relationships between causal clauses and sanction clauses using the *trigger relationship* (Fig. 10).
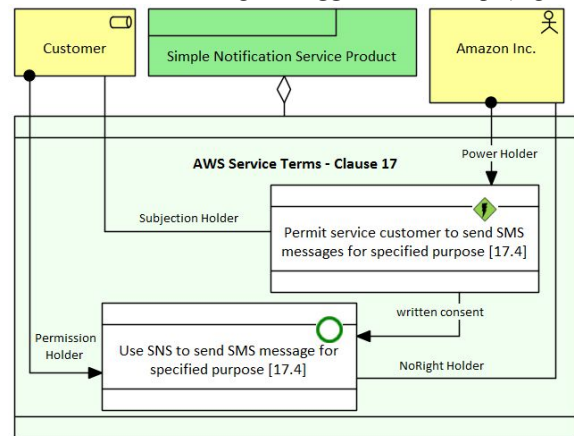

Fig. 11. Fragment of AWS Service Terms – Clause 17.

In applying the method for extracting and representing legal relations, one can visually identify whether a contract is unbalanced, that is, if a party is more protected than her counterpart. This is due to the nature of the existing legal positions in these contracts, i.e.: right, permission, liberty, and power to the detriment of their correlated positions: duty, no-right and subjection. For instance, Figs. 9-11 show fragments representing the AWS Service Terms. Note that most clauses are written to protect the service provider. Usually, cloud service agreements have the legal nature of *adhesion contract*. This means that the economically stronger party establishes the contractual clauses, leaving to the weaker party no opportunity for bargaining. At first sight, this kind of contract seems to benefit the service provider, however, courts often tend to interpret adhesion contracts restrictively, applying, for example, the Reasonable Expectations Doctrine [26] as basis for nullifying contractual clauses or the entire contract.

When constructing the concrete syntax for legal relationships based on the UFO-L ontology, it has been necessary to decide between the expressiveness and the simplicity of the visual constructs set. Firstly, we decide to represent a legal relationship as a whole by means of a relationship between *customer, provider* and *contract* (Fig. 7). Secondly, we chose to represent the contract elements - the existing legal relationships within a contract - in a partial way. In other words, since each legal position correlates to another legal position, we represent the salient legal position in the text by means of an ArchiMate symbol (symbol for *contract*) and we extended it with the visual construct representing the legal position emphasized. Also, we represent the relation between contractual subjects and contract elements with the existing relationship notations in ArchiMate and name them using the UFO-L terminology. Finally, the proposed visual constructs refer to conventional symbols representing road traffic rules and suggest, by their appearance, their meaning. While the colors of the visual decorations added to the ArchiMate's symbols set are linked to their meaning, the colors of ArchiMate's symbols are independent, allowing modelers to use the colors that best suits them for particular tasks.

VIII. RELATED WORK

In this work, we presented two artifacts: an ontology of service contracts and a corresponding extension to the ArchiMate language. These contributions are related to works in the following research niches: contract ontologies, contract languages and languages for legal norms and rules.

With respect to contract ontology, several of them have been proposed in the last decades using a legal perspective. For example: the ontology for international contract law [27]; the Uniform Commercial Code (UCC) Ontology, on legal contract formation [28]; the MPEG Media Contract Ontology (MCO) [29] to deal with rights concerning multimedia assets and intellectual property content; and, the contract ontology based on the SweetDeal rule-based approach [30]. Although not strictly speaking a contract ontology, a conceptual model for deontic concepts is also provided for RM-ODP in [31]. All these approaches employ the monadic operators of deontic logics, not fully capturing the relational aspect that is at the basis of our service contract ontology. With the exception of [27], none of the approaches employ Hohfeld's legal concepts, failing thus to account for rights in a narrow sense. None of them explicitly address *powers*. Also, we observed cases of semantic overload concerning the concept of *right* in some ontologies of contracts (e.g., [32]).

In addition to contract ontologies, several efforts on contract languages have been reported. In [5], a formal system for reasoning is proposed based on the representation of the *contrary-to-duty* concept in the Business Contract Language (BCL). The authors raised some issues for further investigation, such as an improved separation of subject and target roles in a policy expression and the expressiveness of BCL with respect to other legal concepts (right, authorization and delegation). About the first issue, we have suggested in our work that roles are explicitly represented and their legal positions as well [10]. In this case, not only one party is modeled but two parties in the legal relation, each of which plays a different role in the scope of the legal relation. In [33], a contract language called Contract Language (CL) is based on deontic logic to represent concurrent actions. Despite the benefits of a formalism based on concurrent actions, the authors stumble on the semantic overload when they do not distinguish right from permission. For instance, in the example cited to instantiate Postulate 3.8 ("Obligation to an action implies that the action is permitted") it is not correct to state that "the client has the right to pay". The correct assertion is that "the client has permission to pay". This is an instructive example of how the reduction of legal positions to a unique form of right-duty position results in loss of meaning and misunderstanding as discussed in [23]. In [34], the authors propose the transformation of contract constraints of BCL and Finesse into expressions in a service choreography language. In [35], the authors propose a Formal Language for Writing Contracts (FCL) that is based on monadic deontic logic operators of obligations and prohibitions. Obligations are considered the result of 'promises' and permissions are considered the result of 'not promises'. Also, the authors propose a formalism for reparational clauses in contracts. In the last cited languages, we observe the use of monadic operators: obligation, prohibition and permission as the unique way to represent legal positions. There is no representation of *power norms* and other relevant legal concepts (such as right in a narrow sense).

Other languages have been used to model legal aspects in the scope of enterprises and information systems, including, e.g., Rule*ML* [36], LegalRule*ML* [37], and Nòmos 3 [8]. LegalRule*ML* builds up on Rule*ML* uses notions of defeasible logics to treat violation of obligations; in the treatment of violations (which we have only addressed incidentally here) it is more expressive than our ArchiMate extension. With respect to the legal positions that it is able to represent, it does not cover powers or rights in a narrow sense (capturing only the corresponding obligations). (Note that the notion of "Right" that is adopted in LegalRule*ML* corresponds to the notion of protected liberty, which can be accounted for in our ontology with a complex relator composing an unprotected liberty with obligations, following Alexy [12]). In its turn, Nòmos 3 is a conceptual framework for representing laws and regulations that uses the conception of *goals* and Hohfeld's theory to reason about compliance of requirements. Consequently, its concept of liberty as synonym of privilege does not cover all the existing permissions (negative and positive permissions).

IX. FINAL CONSIDERATIONS

This work presented a service contract ontology taking as basis both UFO-S and UFO-L. UFO-S is based on the notion of service commitments and claims for characterizing service relations. In turn, UFO-L is a Core Ontology of Legal Relations based on UFO and grounded on Alexy's Theory of Constitutional Rights. The service contract ontology has been used as a basis to derive a well-founded extension to the ArchiMate language to support the modeling of service contract elements. With the addition of contract elements, we can represent the relevant legal relations which are inherent to service phenomena in real-world business settings.

Regarding future works, we intend to investigate the representation of the legal positions inside organizations (arising from internal regulations and compliance efforts) and in the normative environment outside organizations (arising from laws). These positions are also important to service relationships, which is most evident in the case of consumer law, but is also paramount in highly regulated economic sectors (such as healthcare).

Although we have taken into account some principles proposed by Moody [38], further analysis of the concrete syntax may offer opportunities for improvement. Additionally, once the approach is incorporated into EA tools, new insights may arise from practical application of the syntax, which could inform an *ex post* evaluation effort.

Finally, this work can be positioned in our long-term research agenda concerning the semantics of EA models, and ArchiMate in particular. Since previous work has also employed UFO (and its extensions) as a semantic foundation to revise a number of ArchiMate constructs (including Services [3], Goals [39] and Capabilities [24]), we envision all these efforts can be harmonized to provide a comprehensive well-founded enterprise modeling approach.

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