Towards a Unified Service Description Language for the Internet of Services: Requirements and First Developments

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Abstract

Service-oriented Architectures (SOA) and Web services leverage the technical value of solutions in the areas of distributed systems and cross-enterprise integration. The emergence of Internet marketplaces for business services is driving the need to describe services, not only from a technical level, but also from a business and operational perspective. While, SOA and Web services reside in an IT layer, organizations owing Internet marketplaces are requiring advertising and trading business services which reside in a business layer. As a result, the gap between business and IT needs to be closed. This paper presents USDL (Unified Service Description Language), a specification language to describe services from a business, operational and technical perspective. USDL plays a major role in the Internet of Services to describe tradable services which are advertised in electronic marketplaces. The language has been tested using two service marketplaces as use cases.

1. Introduction

Service-oriented Architectures (SOA) and Web services have mainly served as technological solutions that enable enterprise functionality to be made available to users as shared and re-usable services on a network [1][2]. While many Web services externalize business functionalities, existing specification languages, such as WSDL and BPEL, only target the description of technical characteristics of services. Nonetheless, for enterprises, the true value of services can only be achieved when their business nature and characteristics can be suitably described, made available to consumers, and aligned with the IT perspective [3].

The concept of business service has acquired a renewed importance with the rise of business intermediaries which are creating new market opportunities for services, outside company "firewalls". For example, software-as-a-service ventures are competing against traditional software vendors by leveraging electronic marketplaces for service supply and demand e.g. Salesforce.com. In turn, the creation of whole application suites out of services in wide ecosystems is emerging through so-called Multi-Enterprise Business Process Platforms [17], e.g. e2open. Meanwhile platforms themselves are being offered as services to reduce in-house efforts for B2B interoperability, e.g. message translation offered through Crossgate and Sterling Commerce. Central industries, too, are seeking ways in which services can be accessed and integrated efficiently on global scale. Namely, the European Council has approved a directive to facilitate cross-border market access for services. The directive can amplify the consumption of services by 0.6% (€37 billion) [4]. A strategic technology question is "how can the Internet support a genuine market for the trade of cross-border services?" The Internet is now an integral ingredient of the fabric of worldwide societies and economies, and can provide a trading infrastructure for the Internet of Services (IoS) [5].

While SOA and Web service ecosystems enable intermediaries to procure services through different distribution and delivery channels [6], their main goal is to provide a distributed computing infrastructure for both intra and cross-enterprise application integration and collaboration [2]. Therefore, their pure technical description is not sufficient for the development of suitable solutions for the IoS. The downside of current service specifications is that the gap between the business and the technical perspectives is still open. A business service is concerned with the end-to-end delivery of an added value and outcome, which has a much coarser grain than that of the typical Web service. A business service is delivered by a provider to a consumer possibly over a specified period of time, a payment structure, a service level agreement, and related legal obligations of the consumer and the provider [7].

This paper describes the Unified Service Description Language (USDL) that has been created to capture the business and operational nature of services and align them with the technical perspective. USDL aims at complementing the current Web service stack. We are currently using USDL to describe business services in IoS applications. USDL can be seen as the first step to better understand and describe the fundamental characteristics and peculiarities of business services. Although completeness of USDL is not claimed, its usefulness for a

particular and prominent form of intermediary, namely an electronic marketplace, is demonstrated through two applications.

2. Service Marketplaces

The first intermediaries have been public software registries, providing single-stop brokerage of Web services from diverse sources. Even though they were supported by strong organizations, most of them exhibited a decline after only a few years, e.g., the UDDI Business Registry was operated by Microsoft, IBM and SAP from 2000 to 2006. This can be traced to the fact that the service metadata specified in essentially technical standards is insufficient to facilitate independent discovery of services by consumers: consumers need prior, "offline" knowledge about services that are diversely supplied and not specific to a particular domain. In other words, service semantics was inadequate. Moreover, critical aspects related to service delivery (non-functional ones) were absent. Yet, consumers are reluctant to engage in business transactions without knowing about timeliness, reliability, privacy and settlement.

Service marketplaces have emerged as a later development following the successes of Internet marketplaces (like Amazon and eBay). Table 1 summarizes distinct types of marketplaces and their characteristics.

Marketplace	URL	Service Description	Business Model
Software-as-a-Service marketplaces	www.salesforce.com, www.workday.com, www.webservicex.net	WSDL and structured description and free text	Pay per use, commission fees and rewards
One-stop citizen and constituency services	DirectGov.uk, usa.gov	Link directory and government agency documents.	Cost savings and political incentive for improved efficiency, transparency and community building for government services
Business service marketplaces	AXIOM, Intel Business Exchange, IBM SmartMarket	Structured text and free-text	Best deals, commission fees for referrals Commission fees, referral fee, or via related hardware sales.

Table 1. Classification of marketplaces and their characteristics

Software-as-a-Service marketplaces like Salesforce.com and Workday are similar to public software registries, with key differences: they are governed by a commercial player, they pertain to a specific domain (e.g. CRM in the case of Salesforce and HR in the case of Workday) and they strive for a business model that features pay-per-use pricing and hosting. While they use WSDL to provide technical interfaces, most of the remaining description is presented as structured and unstructured text. Structured text includes a categorization of the service, pricing or provider information. Unstructured text is used to point out the benefits, usage scenarios and policies of the service offer. Overall, these marketplaces focus on a manual search, selection and integration into distributed applications.

Another significant development is *one-stop citizen- and constituency services* through the public sector. Although they are not marketplaces in the strict commercial sense, they have similar features such as bringing consumers (e.g. citizens) and providers (government agencies) a "one-stop" exposure of business services (e.g. land parcel checks and life events) through centralized channels, e.g. DirectGov.uk or usa.gov. These are typically portals that provide links to information and services of governmental agencies. Service descriptions are general and are geared to an audience that has high confidence in accessing exposed services and wishes to avoid inefficient government silos. Being public sector, the emphasis is less on generating revenue, although these platforms do facilitate certain service delivery functions like single-point payment and service tracking. For agency access, gateways underpinning the platforms are useful for technical integration, e.g. usa.gov exposes services like taxation details and street validation which are used by Software-as-a-Service initiatives like Salesforce.

A recent development are *Business Service Marketplaces*, e.g. American Express Intelligent Online Marketplace (AXIOM), Intel Business Exchange or IBM SmartMarket. Business service marketplaces are centrally governed by a dominant commercial player focused on differentiation while deriving adjacent or outsourced services from wide and global partnerships. The dominant player benefits from increased revenue by exposing wide choice and best deals for consumers. Partners also enjoy a greater market visibility for their services. As the range of services on these marketplaces is quite diverse, descriptions are mostly free-text in addition to basic attributes like price, provider details, reputation and categorization.

From our discussion we can summarize that service descriptions in various domains are based on textual descriptions that are presented to consumers to be

discovered and selected. Hence, there seems to be a lack in formalizing non-technical aspects of a service, such as pricing, benefits, quality of service or legal requirements. USDL is an attempt to include such information in a structured way. This may facilitate use cases where services are discovered, selected and integrated into their execution environment with minimal manual interaction. Concluding this section, we will outline the subset of requirements for the USDL perspectives introduced in Section 3.

R1) **Variability:** Services are subject to variations depending on their context of use. In one-stop citizens and constituency services, the user's residential status and jurisdiction typically influences which of the different variants of the same service apply. Another factor is the functional artifact concerning a service. For example, an apparently singular service such as the creation of business licenses entails diverse variants depending on the line of business (e.g. a coffee or flower shop), land adjacency and size (e.g. physical area, number of employees). *A service description language should support different contexts and domains so that different variants of the service can be automatically determined.*

R2) **Bundling:** Related to variability is offering consumers a number of services together, for greater competitiveness or convenience. An obvious example can be seen through Telecommunications companies, combining fixed line, mobile and content services. Using bundling, American Express reported that best deals created through AXIOM saved up to 40% of the $40 billion spent on corporate travel. *A service description language should support the bundling of multiple services into offers which impact pricing among other constraints of service delivery.* The requirement of bundling differs from variability since several services are involved. Furthermore, the basis of "composition" is an offer and not necessarily a functional relationship as with business processes.

R3) **Multiple views:** Providers may retain the option to disclose or not internal operational details to consumers. In wide-reaching marketplaces, intermediaries like B2B integrators or gateways provide dedicated services which need to be carefully composed into pre-existing services. In this case, some internal operational details of services need to be exposed so that newly introduced interactions are risk mitigated. Hence, *a service description language should allow for different views to facilitate the different situations of consumption: consumer (black-box view), intermediaries (grey-box) and providers internal to an enterprise (white-box).* These views should be used in conjunction with service access control and authorization.

R4) **Non-functional conformance:** A service level agreement (SLA) provides conditions of operation, qualifying mutual obligations on the part of consumers and providers for successful service delivery. If SLAs are violated, all partners rely on the terms of use to justify, e.g. penalties. *A service description language should allow for operational constraints on service provisioning based on different situations.* SLA could be monitored during execution and be traced to high-level organizational policies. They could also be used during composition to determine operational compatibility and risks when combining services from different environments. Promises, obligations and penalties should be included.

R5) **Extensibility:** Since service descriptions, in general, and the business perspective, in particular, are often domain dependent, it is not realistic to create a single language that accounts for all the possible characteristics of services. As a result, *a service description language should allow for horizontal and vertical extensions.* Horizontal extensions allow adding new generic perspectives and properties to a service description language, while vertical extensions allow including domain specific descriptions (e.g. from healthcare or finance).

3. Describing Business Services with USDL

A business service is a well defined, encapsulated, reusable and business-aligned capability. Compared to technical services, developing solutions for the IoS is more elaborate since services are generally intangible, often inseparable, immersive, bi-polar/hybrid, variable, ostensible with respect to ownership, have long-running interactions and are decoupled [8].

As such, the Unified Service Description Language (USDL) has been created to provide a solution to describe services from a business, operational and technical (BOT) perspective. Compared to Web services and SOA, the emphasis of USDL is not limited to technical and implementation aspects of services. USDL enables organizations to describe and publish their business services by describing their BOT characteristics to enable consumers to discover and select services. Figure 1 shows an overview of the USDL metamodel with the BOT perspectives.

In order to establish a proper base for USDL, we have chosen a MOF-based metamodel approach to provide a

formal specification. This has allowed a rapid prototyping of USDL editors, parsers and adaptors.

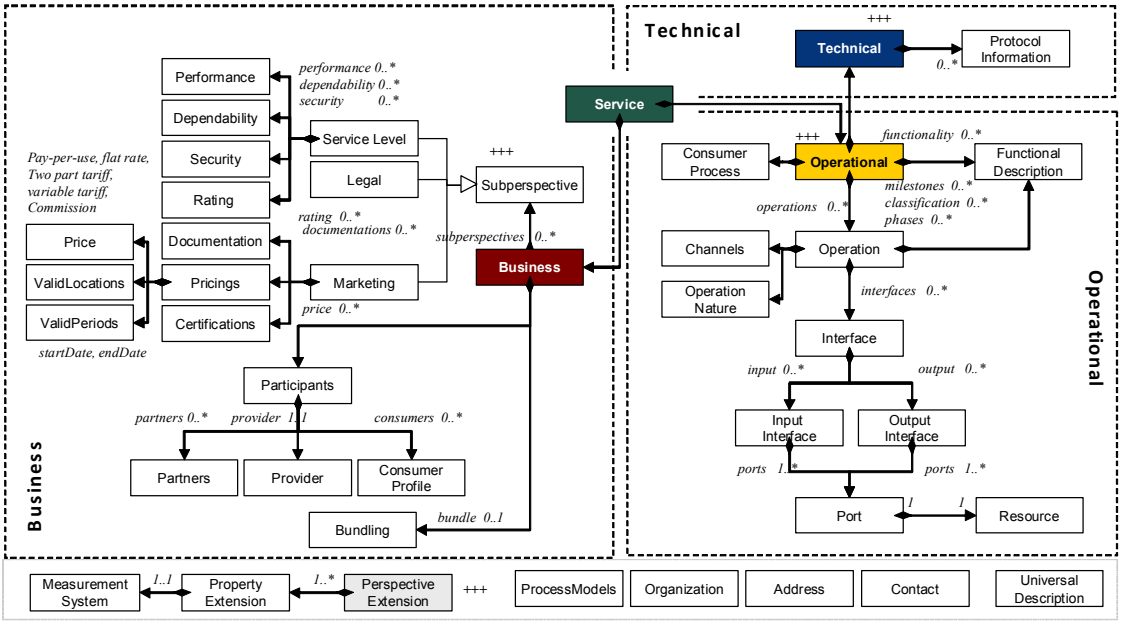

Figure 1. Simplified metamodel view of USDL

USDL builds on the usage of models for describing business and technical services, and creates a unified description of related research efforts. The purely business description of services has been driven by research on the E3Service ontology [9], the PAS 1018 [10], and the taxonomy identified by O'Sullivan [11]. From the technical side, the most significant proposals to describe services that have influenced USDL include WSDL, WSMO, and OWL-S. Additionally, USDL introduces a new dimension called the operational perspective. This perspective acquires a special importance when several participants are involved in the provision of a service.

The class Service is the central element that represents service descriptions. As a result, in USDL, the class Service brings together the Business, Operational and Technical class. Each of the classes (perspectives) is described in the following sections. When no ambiguity arises, we simply use the term service to refer to a business service. In addition, we relate USDL concepts to the requirements introduced in Section 2 (indicated in braces after the concept name).

3.1. Business perspective

USDL includes a business-sensitive perspective that represents a paradigm shift from IT to the enterprise. This shift signals an evolution from a Web service orientation to business service orientation, which links IT services to business goals, strategies and objectives. The business perspective of USDL empowers service descriptions with business concepts such as service quality in terms of consumers' experiences, definition of strategic partners and alliances, marketing strategies, pricing models, service levels, legal constraints, and added value for consumers.

1) Participants (R3). USDL identifies three major players or roles involved in service trading represented with the classes: Provider, Consumers and Partners. The class Provider includes organizational information and the identity of the responsible person for a specific service. Potential consumers are described using profiles. Depending on the use case, consumers may be humans or enterprise systems interacting with an electronic marketplace. These consumers have in common that they have a problem to be solved and a goal to be reached. Therefore, the class ConsumerProfile enables consumers to explore the use of problem-oriented and goal-oriented approaches [12] to determine if a particular service suits its needs. The Partner class provides a model to make explicit associations between a provider and other organizations involved in service provisioning. Types of associations include partnership and alliance. A partnership is a formal association between two or more parties that have agreed to work jointly in the pursuit of common objectives. The agreement targets to joint several origination's funds, skills, resources and talents to provide a service and share the profits and losses. An alliance is a commitment, trust, and mutual agreement to benefit two parties. It is usually motivated with the objective to increase customer satisfaction and reduce

costs. An example is the code sharing program in airline alliances.

2) Service Level (R4). Service level (SL) represents the quantitative and qualitative characteristics associated with a service and are usually represented in a Service Level Agreement (SLA). Quantitative characteristics can be evaluated in terms of concrete measures such as service execution time, availability, performance, reliability, etc. Qualitative characteristics specify the expected features offered by a service such as non-repudiation and encryption. USDL allows specifying four main classes to describe the SL: a) Performance, b) Dependability, c) Security, and d) Rating. Performance is defined as the time(s) needed to deliver a particular service. Dependability is the ability to deliver a service which does what it is intended to do based on SLA binding contracts. The class Security characterizes the security level associated with the execution of a service and includes aspects such as authentication, integrity, confidentiality, and non-repudiation. Finally, USDL uses the class Rating to provide a mechanism managed by marketplaces to establish trust and confidence between providers and consumers based on the feedback received from an interest groups, communities, or experts.

3) Marketing (R1, R3) is often associated with advertising and sales. Its goal is to create a mutually profitable and sustainable relationship between a provider and its consumers. Within USDL, marketing is expressed using the following classes: a) Pricing, b) Documentation, c) and Certification. Pricing indicates the possible pricing model for a service and includes five well-known models: flat-rate (subscription), pay-per-unit, two-part tariff, variable tariff and commission. Additionally, pricing models include a basic structure which includes information about the currency, VAT, payment methods, valid locations, and valid periods. Additional pricing models (e.g. discounts, non-linear models, and auctions) can be defined using the extension mechanism provided by USDL. The class Documentation provides "official" documentation available on the service and supplied by the provider (or broker), as well as postings produced by online communities (blogs, comments, etc.). The documentation may take various human readable forms such as user guides, flyers, promotional campaigns, videos, programmer guides, brochures, etc. The class Certification provides an attestation that a provider has a specialized skill-set, knowledge and experience in a particular field. Examples of well-known certifications include ISO 9000, Project Management Institute (PMI) certification, and Microsoft and SAP certifications.

4) Legal (R4). The provision and consumption of services entails the consideration of legal aspects represented with the Legal class. USDL provides support to indicate the Terms of Use (ToU) and the legal clauses associated with a service which formalize the rights, obligations, and penalties of consumers and providers involved in a transaction. Rights describe the legal or moral entitlement to do or refrain from doing an action. An obligation refers to the behavior that is expected or required from the provider or consumer. Penalties are imposed on any party in the case of violating rights or obligations.

5) Bundling (R2) is a strategy widespread in the industry that involves offering several services for sale as one combined package, compilation or anthology. A bundle is a collection of related services that are gathered because of their added value for consumers as a set. Two types of bundling are supported: pure bundling and mixed bundling. In pure bundling, consumers must buy bundled services together. In mixed bundling, consumers have the choice of buying bundled services or buying one service without the others. In USDL, bundles can be associated with a process model which describes the preferred or advisable invocation ordering of services.

6) Extension mechanisms (R5). Since service descriptions, in general, and the business perspective, in particular, are often domain dependent, it is not realistic to create a language that accounts for all the possible characteristics of services. As a result, USDL includes extension mechanisms that allow creating new sub-perspectives (of the business, operational and technical perspectives) and new properties. Measurement systems can be attached to extensions to associate physical quantities to new properties, allowing to scope and monitor them. For example, the telecommunication domain specific property ASR, the Answer-Seizure Ratio, can be associated with a new measurement system. This feature makes USDL an open specification that can be customized to accommodate particular needs presents in specific industries (healthcare, telecommunications, energy, governments, etc.).

3.2. Operational perspective

The operational perspective is concerned with the elementary operations undertaken to provide a service which brings beneficial change or added value to consumers. The information present in this perspective can be used by providers to manage the required flow of resources to deliver specific services, define its operations

and design resource provision layouts. Consumers can identify how the operations of a service need to be choreographed and providers can define how operations are orchestrated.

1) Operations (R3)**.** USDL follows a system theory approach to describe the operations made available by a service. Each operation has an input interface and an output interface. Interfaces form a contract between the operations of a service and the outside world. This is analogue to the separation of external interfaces from technical systems theory. An interface groups individual ports. Typically, the execution of a service requires and produces resources whether financial assets, parts and materials, documents or forms, or intangible assets such as an individual's skills or an organization's proprietary data [7]. Ports are used to represent resources. The concept of port is important since it enables to abstract away from the intricacies of internal services and focus only on how service operations can be composed based on the resources manipulated. Depending on the level of automation, the nature of an operation can be classified as: manual, automated (or hybrid) and automatic [13].

2) Classification (R3). The class Classification allows associating a service and its operations with one or more categorizations based on standard or private industrial taxonomies. The mechanism can be used by service providers and marketplaces to classify services in order to allow consumers to discover services more efficiently. Historically, classifications have posed problems due to the absence of unanimously accepted classification scheme. Therefore, many authors have developed different methods of classifying services. Over 16 different schemes were identified by Payne [14], using a wide variety of factors ranging from the type of service to the degree of labor intensity required. As a result, with USDL, services may be classified according to multiple classification schemes. Providers and marketplaces can develop their own classification schema (e.g. strikeiron.com marketplace classification or SAP industry segments classification) or rely on standard classification systems (e.g. United Nations Standard Products and Services Code (UNSPSC) and the North American Industry Classification System (NAICS)).

3) Functionality (R3). Functional descriptions are a central pillar of services. This type of description ignores details on how to invoke and execute a service and provide information about what the service does. The USDL approach to the functional description of services is multifaceted since it allows natural language, keywords (i.e., tagging) and ontologies as fundamental structures to express the functionality of a service using an universal description mechanism (see Section 3.4).

4) Phases and Milestones (R1, R3). Phases and milestones introduce concepts borrowed from the area of project management to the description of services. In the area of project management, activities follow a tried and tested sequence. Sequences often result from best practices. Each phase can be interpreted as an agglomeration of operations. Therefore, the created phases provide a high level description of the business process associated with a service. This abstract and implicit process can serve as a basis for service discovery and invocation. The class Milestones allows indicating the achievement of an important stage during a service execution. While a phase marks the beginning and acts as the container for operations and an operation is a specific action that needs to be executed within a phase, a milestone marks the end of a phase and all the operations within. Milestones provide a way to express the major states that a service will reach during its execution.

5) Consumer Process (R3, R5). The class ConsumerProcess contains a reference to a business process model that expresses the external observable behavior of a service. This process model represents and formally encodes the relationships between operations, phases and milestones. No constraints are made with respect to the business process language used. Therefore, depending on the skills of consumers, business process languages such as EPC, BPMN or BPEL can be used.

6) Interaction Channel (R1, R3). The class Channel describes a method of communication with a service. A channel allows different audiences to access a service over various delivery channels. Possible types of interaction channels include phone, fax, e-mail, Web service, software application, physical presence, etc. Each channel provides consumers with access to a subset of the service operations. The capabilities and the presentation style may differ depending on the consumer and the channel. For example, employees might have access to more interaction channels than consumers, who might need different, more robust, and scalable presentation capabilities.

3.3. Technical perspective

The technical perspective acts as a central point to reference existing Internet standards to be used to interact with services and it is divided into seven subsections: transport protocols, messaging protocols, metadata exchange protocols, security protocols, reliable

messaging protocols, transaction protocols, management protocols, and user interfaces. For example, a consulting service may be specified to have HTTPS and SMTP transport protocols, a WS-EventNotification messaging protocol, a WS-ReliableMessaging reliable messaging protocol and a Flex user interface.

3.4 USDL and universal descriptions

To augment the amount of metadata associated with business services in order to enable consumers to better understand their goals and added value for an enterprise, USDL introduces the concept of universal description (UDescription). This class allows adding domain specific semantics and provides an advanced and fairly complete solution to describe each USDL entity as precisely as possible. For example, it can be used to enhance the description of suppliers, partners and resources using syntactic and semantic knowledge.

A universal description includes four elements: a name, a textual description, a set of keywords and a set of ontological concepts. The textual description is to be used by NLP algorithms. Keywords provide a tagging mechanism similar to the one provided by del.icio.us for adding re-usable data to the information space. Ontological concepts provide services with well-defined global ontologies. For example, the attribute concept can be applied to ontologies but can also be used to refer to concepts of classification schemas and taxonomies (such as UNSPSC). The level of metadata support provided by USDL has been pointed out to enable the best results for service matchmaking and discovery [5].

4. Marketplace Applications

First practical experiences with USDL have been collected in the context of 3 projects at SAP Research.

One project explores the space of multi-step process-based services that are common, e.g., in the public sector domain. Services of this type usually encompass a number of providers and intermediaries, which strongly motivates the requirements to have *multiple views* and *non-functional conformance*. For the consumers of such services it is very important to understand the complex interaction protocol that they have to follow during execution. The operational perspective of USDL contains elements necessary to gain these insights (e.g. *consumer process*, *phases*, or *interaction channel*).

The second project, Agora, focuses on manual or automated services like, e.g., customizing software. Such an environment constitutes a classic case where *bundling* and *variability* need to be addressed. In Agora a service bundle contains the services that realize a complex business scenario, e.g. adapting the UI of a software system to the customer's corporate identity. Such business scenarios are not fixed prescription of services, but include options and choices. Bundling requirements like these are well covered by the *mixed bundling* capabilities of USDL. Additionally, the Agora case exemplifies the great diversity of the services economy. Individual services often have very specific properties used to configure their final delivery, e.g. an Analytics Report can be requested in different languages and formats. USDL provides an extension mechanism that allows to make new properties part of the service description. The *measurement system* concept ensures that properties can be correctly captured and processed.

The third project is concerned with the management of services in the ecosystem of a financial services provider. A corporate services directory is used to catalogue internal services and services from business partners in order to enable one-stop access for them. This means services show different levels of granularity and detail depending on who provides them and who wants access. Requirements like *multiple views* and *non-functional conformance* (service levels) are important in this context. What was also discovered is that sometimes simple things are of interest. E.g., knowing the (business) owner of a service, its up-times, as well as associated legal obligations, is crucial in order for service reuse across departments to work. USDL covers such business-related metadata (*participants*, *valid periods*, *legal*).

5. Related Work

The main sources of USDL have already been listed in Section 3. In essence, we combined these sources, technical and business-related service descriptions, to produce a comprehensive description model.

Further related work exists in the area of quality of service (QoS) modeling. There are numerous approaches that associate QoS characteristics with (technical) Web services, e.g. [15]. Although these approaches introduce new elements to a service's description, they typically do not go much beyond measurable service levels, like availability, reliability, response time, or security parameters. Our USDL incorporates these attributes in the *Service Level* sub-perspective. The only "real" business-level QoS attribute usually considered is price (or cost). However, price is mostly represented as a single unstructured value, which does not compare to the comprehensive pricing models supported in USDL.

Finally, USDL also draws parallels with management of service level agreements. The reason is that USDL service descriptions are intended to be blueprints for service contracts, which essentially are SLAs. A similar

approach is described by Dan et al. [16]. While [16] focuses on SLA that can be monitored automatically, USDL also contains elements that primarily are informative and can only be monitored manually (e.g. legal requirements).

6. Conclusions

Marketplaces operating on the Internet of Services (IoS) will provide the opportunity to create and drive a new "service industry" for provisioning, brokering, (re)selling and operating business services. Enabling the trading of services brings a new set of requirements that needs to be addressed. One of the first research questions is to understand the nature and characteristics of business services in order to formalize its non-technical aspects, such as pricing, benefits, marketing, quality of service and legal requirements. Furthermore, the variability of services based on their context, strategic bundling, multiple views, non-functional conformance and extensibility are requirements that need to be considered. Based on these requirements, we have developed the Unified Service Description Language (USDL) which captures the business and operational nature of services and align them with the technical perspective. Having this language as a building block for the IoS, an evaluation of its applicability and suitability has been started using three service marketplace use cases. Further evaluation is planned in the future.

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