

AN ONTOLOGY-BASED SERVICE DISCOVERY APPROACH FOR THE PROVISIONING OF PRODUCT-SERVICE BUNDLES

Abstract

More and more traditional manufacturing companies bundle their products with services to offer integrated solutions. Some of these services can be digitized completely and thus fully delivered electronically. Other services require the physical integration of external factors, but can still be coordinated electronically. In both cases companies face the problem of discovering concrete service offerings in the market. Based on ideas from the web service discovery discipline we propose a meet-in-the-middle approach between heavy-weight semantic technologies and simple full-text search to address this issue. Our approach is able to identify and process semantic and linguistic relations in service descriptions and thus delivers better results than syntax-based search. However – unlike most semantic approaches – it does not require the use of any artificial language and thus requires less resources and skills for both service providers and consumers. To fully realize the potentials of the proposed approach a domain ontology is needed. In this research-in-progress paper we construct such an ontology for the domain of product-service bundles through analysis and synthesis of related work on service description. This will serve as an anchor for future research to iteratively improve and evaluate the ontology through collaborative design efforts and practical application.

Keywords: service discovery, product-service bundles, semantic web services, ontology, ontology design.

1 MOTIVATION

In many economies around the world we are witnessing a transition from a goods-based to a service-based economy (Statistisches Bundesamt 2003). For example, in the U.S. services account for 75% of the gross domestic product (Pal & Zimmerie 2005). There are several reasons for the growing importance of services. While the provision of technology is more and more becoming a commodity which can be almost equally provided by different companies, services are a means to more differentiated offerings and to superior value creation. Thus many companies use services as a defence against the ongoing commoditization of goods and as a strategy for gaining productivity, retention and growth (Allmendinger & Lombreglia 2005).

More and more traditional, goods-based manufacturing companies are bundling their products with related services to offer integrated solutions instead of solitary physical goods or stand-alone services (Statistisches Bundesamt 2003, Lay 2006, Sturm & Bading & Schubert 2007). In these product-service bundles it is often the service part which is contributing the larger proportion of revenues (Allmendinger & Lombreglia 2005). For example, in the German mechanical engineering sector the profit margin of product-related services (10 %) is significantly higher than the margin of the physical product itself (2.3 %) (Oliver Wyman 2003).

At the same time advances in information technology provide significant opportunities for the provisioning of services via the Internet (Rai & Sambamurthy 2006, Baida & Gordijn & Omelayenko 2004). Some services can be digitized completely (e.g. information services, distribution of software and media, remote diagnostics) and fully delivered electronically. Other services require the physical integration of external factors (e.g. maintenance, cleaning, recycling). However, these services can still be discovered, requested, coordinated and paid for over the Internet (O'Sullivan 2006). In both cases companies, who want to complement their physical products with services, face the problem of identifying such services. This decision comprises, besides important issues of service development and evaluation (which will not be covered here), the discovery of existing service offerings in the market. Service discovery can be described as the task of matching the needs of a potential service consumer with the offerings of service providers (O'Sullivan 2006). The discipline of web service discovery offers many approaches in this respect, which can be roughly divided into three categories (Garofalakis et al. 2006):

Comparable to "Yellow Pages", a catalogue-based approach like UDDI (Universal Description, Discovery and Integration) allows publishing web services as well as traditional bricks 'n' mortar services in a central repository. Services are described using commonly agreed categorization criteria (i.e. metadata) such as industry sector, service provider, service description and technical properties, which users can use to browse the catalogue (Oasis 2004). Although this approach seemed promising in the beginning, it did not stand the test in practice. Especially in inter-company scenarios the categorization criteria were hard to agree upon and tended to get out of hand. In the end the UDDI-registries of the major players IBM, Microsoft and SAP were switched off in 2005.

A second class of approaches builds upon information retrieval techniques. Information retrieval (IR) is concerned with the content-based search (as opposed to metadata-based search) for natural language documents within large data pools (e.g. searching for web sites on the World Wide Web) (Salton & McGill 1987, Kuropka 2004). In the context of web service discovery full-text search is a widely used approach and is often applied in specialized web service registries and search engines (e.g. ProgrammableWeb.com, XMethods.com) as well as in general search engines (e.g. google.com) (Hagemann & Letz & Vossen 2007). Search queries are expressed in simple natural language terms and due to its broad diffusion on the World Wide Web users are quite familiar with this kind of search. However, it is solely based on syntax and thus very sensitive to linguistic phenomena like synonyms and homonyms. This is a serious issue in the context of service discovery, as one cannot assume that

different service provider and consumer use the same vocabulary to express service descriptions and queries.

In reaction to the inadequacies of syntax-based search, approaches which adopt semantic web technologies (Berners-Lee & Hendler & Lassila 2001) were developed. By using artificial, formal languages (e.g. OWL (Bechhofer et al. 2004), WSML (Bruijn et al. 2005a)) to describe services (and queries) they aim at enabling software systems to semantically understand the functionality and conditions of a web service. Besides the formal language, this requires a formalization of the relevant domain knowledge, e.g. in form of an ontology. An ontology is an explicit specification of an abstract, simplified view of the world one wants to represent (Gruber 1993). It comprises the concepts inherent in this view, the linguistic terms we use for them and interrelationships between concepts. These elements build the basis for semantically describing services using machine-processable, logical expressions which use ontology concepts as axioms. So far the success of semantic web services is modest, primarily because the required effort, knowledge, and skills for building appropriate domain ontologies and describing services using formal languages are enormous.

Based on ideas from the web service discovery discipline we propose a novel approach to service discovery to support the provisioning of product-service bundles. Our approach builds upon the enhanced Topic-based Vector Space Model (eTVSM) (Kuroпка 2004). eTVSM is an advanced information retrieval technique which is supported by the use of ontologies to consider topical and linguistic relationships between domain concepts. Thus it represents a meet-in-the-middle approach between approaches using formal languages (e.g. OWL, WSML) and simple information retrieval approaches (i.e. natural language full-text search). As eTVSM requires a domain ontology to deliver quality search results, our aim is to initiate a collaborative research process to design such an ontology for the domain of product-service bundles. In this paper we present an initial ontology created through a synthesis of existing ontologies and conceptual models for service description to anchor this collaborative design process.

The remainder of this paper is structured as follows: In section two we introduce eTVSM and its application for service discovery. In section three we present an initial ontology for an eTVSM-based service discovery. We analyse related work on service description and based on these findings construct a comprehensive ontology covering both business-related as well as information systems-related concepts. We conclude this paper with an outlook on the planned future research process to evaluate and improve our approach.

2 THE ENHANCED TOPIC-BASED VECTOR SPACE MODEL AND ITS USE FOR SERVICE DISCOVERY

The essential idea of using eTVSM for service discovery is to express service descriptions and queries in natural language documents which are analyzed by a search engine using a given domain ontology. The search engine scans description and query documents for concepts inherent in the domain ontology and constructs so-called concept vectors. Matching is performed by calculating the similarity between concept vectors. Finally, the user is presented with relevant service descriptions ordered by the similarity level of the corresponding vectors. It is important to emphasize that our aim is not to automate the process of service discovery (e.g. by implementing the presented method into software agents), but to enhance the quality of search results by considering topical and linguistic relationships between domain concepts. The procedures to model eTVSM ontologies and obtain concept vectors and concept vector similarities are described in the following chapters.

2.1 Modelling eTVSM ontologies

eTVSM's basic idea is rooted in the classic Vector Space Model (VSM) (Salton & Wong & Yang 1975). However it provides some significant modifications. The main advancement is, that eTVSM

does not suffer from the false assumption that two different terms have to be independent (orthogonal). eTVSM represents description and query documents as term vectors in a vector space. Relations between terms are expressed through vector angles, which express the level of semantic similarity between terms. To construct term vectors and calculate their similarities eTVSM utilizes the structure of a to be provided domain ontology.

To model domain ontologies eTVSM offers the concepts of terms, interpretations and topics (see entity-relationship diagram in figure 1). These concepts are organized in a hierarchical, non-cyclic directed graph structure. Edges of the graph aim to specify semantic relations of concepts. The concept of topic is the most general semantic entity of an eTVSM ontology. All concepts connected to a topic are considered on-topic, i.e. they are in scope of the current topic. Topic relations are expressed in a topic map. A topic map is a directed graph with topics as nodes. Graph edges assign super-sub-topic relations. The only constraint on the topic map structure is that directed edges must not form cycles. Edges can be typed freely; e.g. is-a, part-of, member-of, or instance-of. A graph consisting of jointly connected topics represents a domain of discourse. Within this graph all topics gain some level of similarity based on the amount of intermediate topics in the topic map structure. The concept of interpretations represents intermediate links between topics and terms. Conceptually, interpretations play the role of semantic terms. By introducing this intermediate concept the modeller of a domain ontology receives more freedom and opportunities to express linguistic phenomena. Mapping two terms to the same interpretation expresses total synonymy. An interpretation can be linked to an arbitrary number of topics. However, links between interpretations are not allowed. Terms are treated as the smallest unit of information that has one or several semantic interpretations. To express this multiplicity in semantic meanings, terms might be linked with an arbitrary number of interpretations. Such a link might be further enriched with support terms. Support terms are terms that frequently co-occur with a specific term. The role of support terms is to explain semantic meaning of term-interpretation links. They are intended to be used for disambiguation of term interpretations, i.e. to find a proper decision what is the “right” interpretation of a term (in case it might have several ones). Terms can consist of an arbitrary number of words (e.g. *web service*). This allows assigning compound terms to an interpretation rather than attempting to find appropriate interpretations for parts of the string tokenized by space characters (two terms – *web* and *service*).

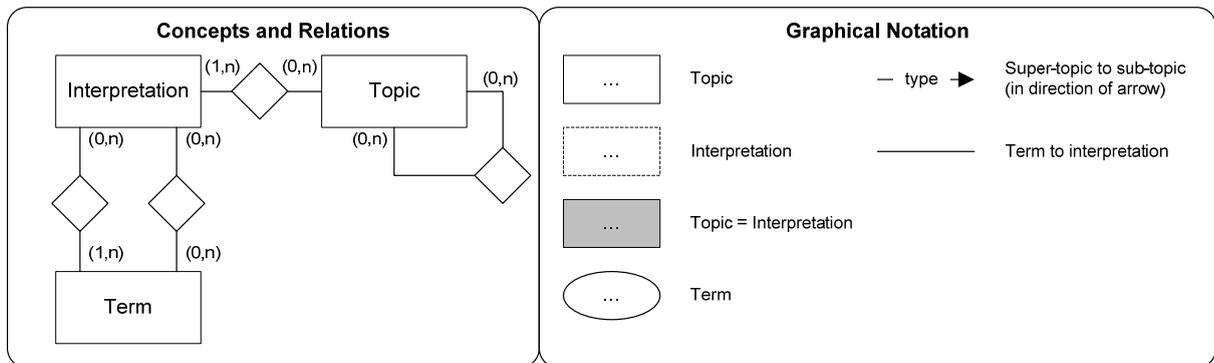


Figure 1. eTVSM ontology concepts, relations and graphical notation

Evaluation has shown that the quality of an eTVSM-based system greatly depends on the ontology upon which it operates (Polyvyanyy & Kuropka 2007). For this reason it is important to facilitate the process of modelling eTVSM ontologies as far as possible. Figure 1 shows a graphical modelling notation for the eTVSM ontology concepts (for an exemplary eTVSM ontology see figure 2). In addition to the already introduced concepts a shortcut is introduced for cases in which topics and interpretations have the same name or are hard to distinguish.

2.2 Obtaining concept vectors and similarities

The process of obtaining concept similarities can be subdivided into two routines: First, eTVSM procedures for gaining concept vectors from the structure of the ontology are applied. Second, concept similarities are obtained as the scalar product of concept vectors. In the following we illustrate this procedure exemplary for the topic concept (for a detailed explanation of the complete procedures see Kuroпка 2004).

In order to represent a topic map structure we can use a super-topic relation $S(\tau_i) \subseteq (\theta \setminus \tau_i)$ – a set of direct parent topics of topic τ_i . Being t the number of topics in a topic map, a set of all topics is given by $\theta = \{\tau_1, \tau_2, \dots, \tau_t\}$. Finally, by defining a set $S(\tau_i)$ for each topic we can completely define the structure of a topic map. The super-topic relation allows us to construct more complex relations, such as a p -level super-topic relation. This transitive relation provides super-topics that are p levels above the target topic:

$$S^p(\tau_i) = S(\tau_i) \quad \text{for } p = 1$$

$$S^p(\tau_i) = \bigcup_{\tau_k \in S^{p-1}(\tau_i)} S(\tau_k) \quad \text{for } p > 1$$

To obtain all super-topics of a target topic we can use an unbound transitive super-topic relation: $S^*(\tau_i) = S^1(\tau_i) \cup S^2(\tau_i) \cup S^3(\tau_i) \cup \dots$

A set of leaf topics θ_L contains all topics that are not included in any super-topic relation of any topic from a topic map, which means that they do not have any sub-topics: $\theta_L = \{\tau_i \in \theta : \neg \exists \tau_k \in \theta \text{ with } \tau_i \in S(\tau_k)\}$

Complementary to θ_L is a set of internal topic nodes – θ_N . θ_N includes topics that have at least one sub-topic: $\theta_N = \theta \setminus \theta_L$

The approach for gaining topic vectors is twofold. In case of leaf topics, topic vectors are obtained as:

$$\forall \tau_i \in \theta_L : \tau_i = \left(\tau_{i,1}^*, \tau_{i,2}^*, \dots, \tau_{i,t}^* \right) \text{ with } \tau_{i,k}^* = \begin{cases} 1 & \text{if } \tau_k \in S^*(\tau_i) \vee i = k \\ 0 & \text{else} \end{cases}$$

In case of internal topics, topic vectors are obtained as: $\forall \tau_i \in \theta_N : \tau_i = \left| \sum_{\tau_s \in \theta : \tau_i \in S(\tau_s)} \tau_s \right|$

The heuristic behind this approach is as follows: Leaf topics are seen as a specialization of their super-topics. Hence, all dimensions of a vector that correspond to the set $S^*(\tau_i) \cup \tau_i$ acquire the same value. Afterwards, the topic vectors are normalized to the length of 1. Once all leaf topic vectors are constructed, topic vectors for topics from set θ_N can be constructed. As an internal topic is a generalization of its direct children they can be obtained as the sum of their direct children. Again normalization is performed: $\forall \tau_i \in \theta : |\tau_i| = 1$

Once we have all topic vectors we can obtain the similarity of two topics as the scalar product of the corresponding topic vectors. Because topic vectors are normalized, the scalar product is equal to the

cosine of the angle β_{ij} between topic vectors: $sim(\tau_i, \tau_j) = \tau_i \tau_j = \sum_{k=1}^t \tau_{i,k} \tau_{j,k} = \cos \beta_{ij}$

2.3 Obtaining document similarity

eTVSM aims at obtaining the similarity of two natural language documents (Kuropka 2004; Polyvyanyy & Kuropka 2007). Therefore, prior to the actual matching procedure vector-based models of the source documents have to be constructed. An eTVSM document model is a set of concepts present in the eTVSM ontology that characterize the semantic meaning of terms used in the document. Hence, document similarity can be interpreted as similarity between two sets of ontology concepts.

The first step in obtaining a similarity measure is to derive a document vector that represents document $d_j \in D$ (D is a set of documents) in an eTVSM operational vector space. A document vector is defined as:

$$\forall d_j \in D : d_j = \frac{1}{|\delta_j|} \delta_j \Rightarrow |d_j| = 1 \quad \text{with} \quad \delta_j = \sum_{\phi_i \in \Phi} \omega_{d_j, \phi_i} \phi_i$$

Here, ω_{d_j, ϕ_i} is the weight of the concept ϕ_i in the document d_j , which might be a simple occurrence count within the document. The document vector is a weighted sum of concept vectors included in the document model. Once more, document vectors are normalized to the length of 1. The document vector length is obtained as:

$$|\delta_i| = \left| \sum_{\phi_k \in \Phi} \omega_{d_i, \phi_k} \phi_k \right| = \sqrt{\left(\sum_{\phi_k \in \Phi} \omega_{d_i, \phi_k} \phi_k \right)^2} = \sqrt{\left(\sum_{\phi_k \in \Phi} \omega_{d_i, \phi_k} \right)^2} = \sqrt{\sum_{\phi_k \in \Phi} \sum_{\phi_l \in \Phi} \omega_{d_i, \phi_k} \omega_{d_i, \phi_l} \phi_k \phi_l}$$

Finally, the similarity between two documents d_i and d_j is obtained as the scalar product of the corresponding document vectors. Considering the document vector normalization, the similarity value becomes equal to the cosine of the angle between document vectors:

$$sim(d_i, d_j) = d_i d_j = \frac{1}{|\delta_i|} \delta_i \frac{1}{|\delta_j|} \delta_j = \frac{1}{|\delta_i| |\delta_j|} \delta_i \delta_j = \frac{1}{|\delta_i| |\delta_j|} = \sum_{\phi_k \in \Phi} \sum_{\phi_l \in \Phi} \omega_{d_i, \phi_k} \omega_{d_j, \phi_l} \phi_k \phi_l$$

Figure 2 summarizes the steps involved in constructing eTVSM document models in form of concept vectors and obtaining similarities between these vectors (see Polyvyanyy & Kuropka 2007 for a detailed description of this procedure). The example illustrates how eTVSM is able to resolve linguistic phenomena like homonyms (the term *service*) and to make out the topic of a document without the use of any artificial, formal language.

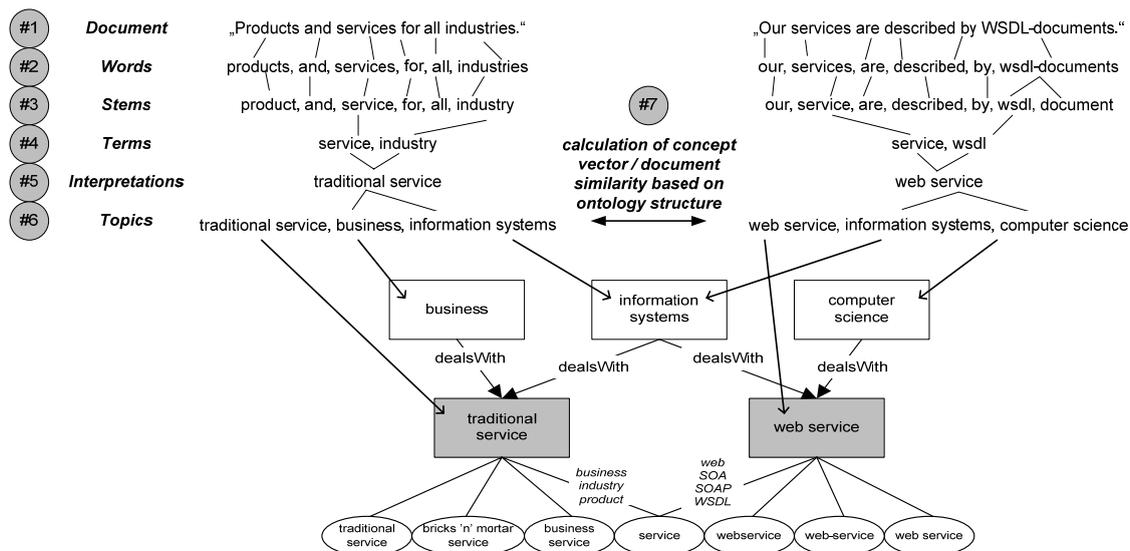


Figure 2. Exemplary application of eTVSM

3 CONSTRUCTING AN ONTOLOGY FOR AN ETVSM-BASED SERVICE DISCOVERY

As explained above, to fully realize the potential of the proposed eTVSM-based approach a domain ontology is needed, which contains the key concepts of the domain as well as their topical and linguistic relations. Many approaches to ontology design have been proposed (e.g. Ushold 1996, Holsapple & Joshi 2002). We decided to use a collaborative approach in which multiple individuals with different viewpoints about the domain are cooperating to iteratively produce a joint ontology (Holsapple & Joshi 2002, Siorpaes & Hepp 2007). This raises chances to gain broad acceptance of the ontology. To start this collaborative design process an initial ontology is used as an anchor. This initial ontology is constructed by synthesis of existing ontologies, conceptual models and other works (e.g. standards) of the services domain. By doing so, we try to produce a largely complete and content-rich ontology with reasonable effort.

3.1 Analysis of related work on service description

In a literature review six promising approaches to service description could be identified. They cover both, a business-oriented (Emmrich 2005; Baida et al. 2005, 2006; DIN 2002; O’Sullivan 2006) as well as a primarily information systems-oriented (Martin et al. 2004; Bruijn et al. 2005) perspective of the services domain. The comparison unveils that each of the analyzed works only provides a partial characterization of the domain (see table 1). Emmrich’s model explicitly deals with product-service bundles and comprises many supply-side concepts. Though, technical issues concerning the electronic provisioning of services are not addressed. The E3Service Ontology comprises well-accepted concepts from marketing research and provides valuable inputs in this respect. But important aspects in the context of product-service bundles, like the consideration of external factors, are missing. O’Sullivan offers extensive and rich input on the description of non-functional service properties and provides an XML-based formalization. Unfortunately it does not take into account semantic or linguistic relations. PAS 1018 represents an almost complete approach from a business point of view. However, it does not cover technical aspects and the domain knowledge is only presented in form of a semi-structured list. OWL-S and WSMO both contain all necessary information on the electronic provisioning of services and include a machine-processable representation. Yet, the coverage of business-related topics is insufficient.

Concept		Approach							Comment
		Conceptual model of product-oriented services (Ermrich 2005)	ESService oriented (Baïda et al. 2005; 2006)	PAS 1018 (DIN 2002)	Taxonomy of non-functional service properties (O'Sullivan 2006)	OWL-S (Marin et al. 2004)	WS/MC (Buijn et al. 2005b)		
Business-oriented	Product	Service	X	X	X	X	X	X	
		(Physical) product	X		X			X ¹	1) link to related physical products
		Structures and categories	X ¹	X ²	X ³	X	X ³	X ³	1) product life cycle 2) service bundles 3) taxonomies (e.g. UNSPC, eCi@ss)
	Properties	Function	X	X	X	X	X	X	
		Quality	X	X	X	X	X ¹	X ¹	1) software quality (e.g. response time)
		Quantity	X	X	X	X			
		Process	X		X		X ¹	X ¹	1) web service invocation sequence
		Time	X	X	X	X			
		Location		X	X	X		X	
	Terms	Price	X	X	X	X ¹		X	1) contains very detailed descriptions
		Payment terms	X		X	X ¹			1) contains very detailed descriptions
		Delivery terms	X		X	X			
		Contract duration			X	X			
	Customer	Needs, wants, demands		X					
		Benefit	X	X					
	External factors	Customer	X		X				
		Information	X		X				
		Rights	X		X	X			
		Physical object	X		X				
	Provider	Provider	X	X	X	X	X	X	
		Potentials	X		X	X			
		References			X	X			
		Ratings			X	X			
		Certifications			X	X			
		Intellectual property			X	X			
	Interfaces	Organizational interfaces			X				
Technical interfaces			X	X ¹		X ²	X ²	1) technical interfaces (e.g. connector plugs) 2) software interfaces (e.g. WSDL)	
Information Systems-oriented	Functionality	Web Service					X	X	
		Input					X	X	
		Output					X	X	
		Pre-Condition					X	X	
		Post-Condition / Effect					X	X	
	Composition					X	X		
	Realization	URI				X	X	X	
		Protocols					X	X	
		Message formats					X	X	
		Other technical specifications					X	X	

Table 1. Comparison of analyzed approaches to service description

3.2 A comprehensive ontology for service discovery

None of the analyzed approaches provides a satisfactory solution to the problem of service discovery in the context of product-service bundles. Consequently we tried to combine the most promising concepts of each work into an integrated ontology appropriate for the description of both business-related as well as information systems-related aspects.

Our ontology is centred on the concept of service (Figure 3). We understand services in the traditional way as economic activities that result in mostly intangible outcomes or benefits and carried out on behalf of someone else (for a discussion of different definitions see for example Baida & Gordijn & Omelayenko 2004).

Services are described by properties. Due to the distinctive nature of services (e.g. intangibility, perishability, consumption at point of production, integration of external factors) physical properties, as used for the specification of goods, are inappropriate for service description. Therefore we have to rely on functional and non-functional properties. The key property of a service is an unambiguous description of its function (i.e. what it does). This should comprise effect (i.e. change in state of the consumer or his physical or intangible assets) and customer benefit. The separation between service and function is essential. The concept of function can be interpreted as a kind of need or problem statement, whereas a service offers a solution to the problem. This enables us to model different services which pursue the same function (e.g. function “communication with others” can be fulfilled by the services “e-mail”, “instant messaging” or “mobile phone service”). Thus the potential customer can search for an undefined service satisfying his functional needs without already considering a solution approach or concrete service offering. Based on their functional description services can be assigned to standardized categorization schemes or taxonomies (e.g. UNSPSC, eCI@ss) to ease discovery, analysis, and selection of services. Additionally, in the context of product-service bundles a categorization based on the life cycle phase of the related physical product (e.g. planning, sale, use, after-use) is often helpful. The non-functional properties exhibit constraints over the functionality. This includes service quality (e.g. with respect to a standard or benchmark) and quantity (i.e. units to be delivered) as well as availability in terms of location (i.e. geographical region or virtual location like URI) and time (i.e. timeframe in which the service can be requested and/or delivered). Supplementary the process of service provisioning might be of interest for potential consumers. The non-functional properties play an important role in service discovery as they enable the customer to compare service offerings with equal functionality.

The same applies for contractual conditions. Typical conditions which are part of the contractual relationship between service provider and service consumer are price (i.e. amount being charged for service provisioning), payment terms (i.e. the manner in which the consumer can pay the charged amount), delivery terms (i.e. the manner in which the service result is delivered to the customer) and contract duration (e.g. subscription time).

In many procurement situations not only properties and conditions of the service itself but also of the service provider can swing a decision. Particularly, if one plans to establish a long-term relationship with a specific service provider. For this purpose service providers are described by the concept of qualification. Qualifications enable a provider to continuously provision an offered service on a certain quality level. In the context of service management capabilities (e.g. know-how, experience, special equipment), references (e.g. project examples, success stories), ratings (e.g. independent benchmarks), certifications (i.e. adherence to security or privacy standards), and intellectual property rights (e.g. patents, copyrights, trademarks) are common means to express such qualifications.

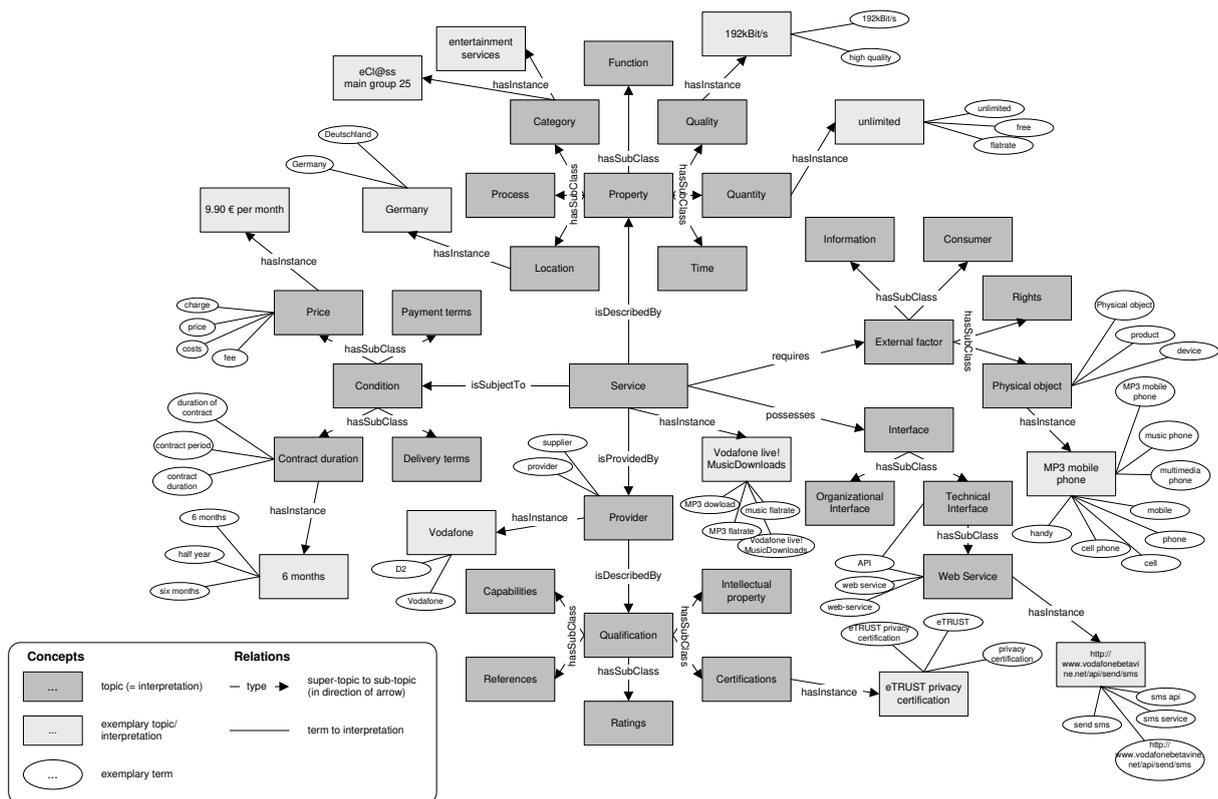


Figure 3. Services ontology including exemplary instances and terms

Another distinctive feature of services is the high degree of interaction between service provider and consumer. Service provision regularly requires the integration of external factors. This can comprise the customer himself (e.g. in case of education services), information (how the service should be performed), rights (permissions in regard to the environment in which the service is performed) or a physical object (e.g. product or resource). For service discovery in the context of product-service bundles especially the later is of high interest. It enables the customer to explicitly search for services which can be combined with a specific physical product (e.g. maintenance for certain model of car, ringtone downloads for a specific mobile phone). As required external factors greatly influence the cost-benefit ratio for the customer they are key information to be included in a comprehensive service description.

During the different stages of the service life cycle customers as well as other participants may need to interact with the service or service provider. For this purpose we introduced the concept of interfaces. We distinguish between organizational and technical interfaces. Organizational interfaces allow coordinating service provisioning with involved organizational units (e.g. key account, help desk) and business processes (e.g. a transportation service with the production schedule of a manufacturer). Technical interfaces enable electronic discovery, request, coordination and provisioning of services. Web services are one example of such technical interfaces. We have decided not to model technical details of web services (e.g. inputs, outputs, protocols, message formats), as it is not our aim to automate service discovery (see chapter 2). Similar to necessary external factors, interfaces are vital information in the context of service discovery. For instance, it allows for the identification of services which can be delivered digitally over the Internet or are in line with implemented business rules or processes.

4 SUMMARY AND OUTLOOK

In this research-in-progress paper we have outlined a novel approach to service discovery, tailored to support the provisioning of product-service bundles. The advantage of our approach compared to simple information retrieval techniques (e.g. full-text search) is the higher quality of search results due to the consideration of topical and linguistic relations of domain concepts and terms. Compared to heavy-weight approaches adopting semantic web technologies our approach requires less resources and skills for both service providers and consumers, as it does not rely on the use of artificial, formal languages. To deliver these benefits eTVSM needs an ontology of the services domain on which it can operate. We have presented a draft of such an ontology, which we have developed based on an analysis and synthesis of both business-oriented and information systems-oriented literature on service description.

This initial ontology is the starting point for future research which will concentrate on the iterative improvement of the ontology and the prototypical application of eTVSM for service discovery, primarily in the context of product-service bundles. To further improve the ontology design we will continuously gather and analyze evolving technical terms of the domain (to identify linguistic phenomena) and actual service descriptions (to generate instance data for the ontology) in an internet research. This information is used to evaluate the application of the ontology and serves as a valuable input for identifying missing or unnecessary ontology concepts and terms. Additionally we plan to build up a community of diverse domain and method experts comprising researches and practitioners. The community will be provided with a web-based software tool to visualize and discuss the ontology in a Delphi-like consensus building process (Lindstone & Turoff 1975).

First evaluations proving the advantages of eTVSM over other vector space models have already been performed (Polyvyanyy & Kuropka 2007). However further evaluation of effectiveness, efficiency and usability, especially compared to semantic approaches using formal languages and compared to simple full-text search, for both eTVSM and the ontology itself is needed.

Parallel to these activities we are currently working on the integration of an eTVSM implementation – which is published under the General Public License (GPL) and available for download (<http://sourceforge.net/projects/etvsm>) – into the central registry of a service oriented architecture (SOA) prototype for the flexible and efficient provisioning of product-service bundles within organizational networks. The prototype is part of a research project funded by the German Federal Ministry of Education and Research (BMBF).

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