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

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Abstract

More and more traditional manufacturing companies form or join inter-organizational networks to bundle their physical products with related services to offer superior value propositions to their customers. Some of these product-related 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 and consumers face the problem of discovering appropriate product-related service offerings in the network or 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 boolean search to address this issue. Our approach is able to consider semantic relations in service descriptions and queries and thus delivers better results than syntax-based search. However – unlike most semantic approaches – it does not require the use of any formal language for semantic markup 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, ontology, ontology design.

1 MOTIVATION

In many economies around the world we are witnessing a transition form a goods-dominant to a service-dominant economy (Vargo & Lusch 2008). Today, in the U.S. services account for more than 75% of the gross domestic product (Pal & Zimmerie 2005). One reason for the growing importance of the service sector is the fact that the production of physical artefacts is more and more becoming a commodity which can be almost equally provided by a growing number of companies around the world. In this situation services are a means to more differentiated offerings and superior value creation. Hence, more and more traditional manufacturing companies start bundling their products with related services to offer integrated and tailored solutions to their customers (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 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 product-related services via the Internet (Rai & Sambamurthy 2006, Baida & Gordijn & Omelayenko 2004). Some services, which can be digitized completely, (e.g. information services, distribution of media, software updates, remote diagnostics) can be fully delivered electronically. Other services, which require the physical integration of external factors, (e.g. installation, repair, recycling) can still be discovered, requested, and coordinated over the Internet (O'Sullivan 2006).

As today's highly specialized companies seldom posses all necessary resources for the efficient provisioning of complete product-service bundles, these bundles are often provided by inter-organizational networks. Famous real word examples for such networks consisting of manufacturers and service providers can be found in the mobile phone industry (e.g. Apple iStore and AppStore, Nokia Ovi) as well as in the automobile industry (e.g. GM OnStar, BMW Assist). In these networks, manufacturers as well as consumers face the problem of identifying appropriate service offerings which fit their individual needs.

We believe the discipline of web service discovery offers promising approaches in this respect. Web 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). Existing approaches can roughly be divided into three categories (Garofalakis et al. 2006):

Comparable to the "Yellow Pages", catalogue-based approaches like UDDI (Universal Description, Discovery and Integration) allow publishing web services as well as traditional bricks 'n' mortar services in a central repository. Services are described using commonly agreed categorization criteria 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-organizational 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 of in 2005.

A second class of approaches builds upon information retrieval models. Information retrieval is concerned with the (content-based) search for unstructured natural language documents within large data pools (Salton & McGill 1987). In the context of web service discovery the boolean model is the most-widely applied technique and is heavily used in both specialized web service search engines and registries (e.g. ProgrammableWeb, XMethods) as well as in universal search engines (e.g. Google, Yahoo) (Hagemann & Letz & Vossen 2007). Due to its broad diffusion on the World Wide Web users are quite familiar with this approach. However, simple boolean search is solely based on syntax and thus does not take into account semantic phenomena (e.g. synonyms, homonyms). This is a serious issue in the context of service discovery, as one cannot assume that service provider and consumer use the same vocabulary and posses the same domain knowledge when expressing their offerings and needs.

In reaction to the inadequacies of the above described approaches, techniques which adopt semantic web ideas (Berners-Lee & Hendler & Lassila 2001) were developed. By using formal languages (e.g. OWL (Bechhofer et al. 2004), WSML (Bruijn et al. 2005a)) to add semantic markup to service descriptions (and queries) they aim at enabling software systems to "understand" the capabilities and conditions of a web service. Besides the formal language, this requires the formalization of the relevant domain knowledge in the 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, their attributes and interrelationships as well as the linguistic terms we use for them. These elements build the basis for the semantic description of services applying machine-processable, logical expressions which use ontology constructs 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 the above described ideas we propose a novel approach to service discovery, which can be used to support the efficient provisioning of product-service bundles in inter-organizational networks. Our approach is based upon the enhanced Topic-based Vector Space Model (eTVSM) (Kuropka 2004, Polyvyanyy & Kuropka 2007). eTVSM is an advanced information retrieval model for the search of natural language documents which is able to consider semantic relationships between terms by exploiting the domain knowledge of a to be provided ontology. Hence, it represents a meet-in-the-middle approach between the above described extremes. Our goal is to develop a prototypical web platform for the provisioning of product-service bundles incorporating eTVSM as a mechanism for service discovery. For doing this, we want to initiate a collaborative research process to design an ontology on which eTVSM can operate. To seed this research process this paper presents an initial ontology draft created through the synthesis of appropriate ontologies and conceptual models which could be identified in literature.

The remainder of this paper is structured as follows: In section two we explain eTVSM and its application for service discovery. We also present first evaluation results. In section three we introduce the draft of an initial ontology for an eTVSM-based service discovery. We first analyse related work on technical and managerial aspects of service description and then, based on these findings, construct a comprehensive ontology integrating both perspectives. We conclude this paper with an outlook on future research activities.

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

The rationale behind using eTVSM for service discovery is straightforward: Both, service descriptions as well as queries are represented by natural language documents. In a two-step procedure a matching engine first scans these documents for concepts (terms, to be more precisely) inherent in the provided domain ontology and constructs document vectors for each document. The actual matching is then performed by calculating similarity values between the document vectors of the query and the service descriptions. Finally, the user is presented with a list of service descriptions ordered by similarity level. It is important to emphasize that our aim is not to automate the process of service discovery (e.g. by implementing the presented approach into software agents), but to enhance the quality of search results by considering semantic relationships between natural language terms. The procedures to model ontologies, construct concept vectors and similarity matrices, and calculate similarity values between documents are described in the following three sections. Finally, we show some first evaluations.

2.1 Modelling a domain ontology

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 are independent (orthogonal) of each other. eTVSM represents documents and queries as vectors in a vector space. Relations between concepts are expressed through vector angles, which express their level of semantic similarity. To extract document vectors and calculate their similarities eTVSM requires a domain ontology.

To model domain ontologies eTVSM offers three concepts: 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. Topics are 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 which 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. Interpretations represent 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 semantic 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 (e.g. in case of homonyms) semantic interpretations. To express this multiplicity in semantic meaning terms might be linked with an arbitrary number of interpretations. Such a link might be further enriched by 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 of what is the "right" interpretation of a term (in case it might have several ones). Terms can consist of an arbitrary number of words. This allows assigning compound terms to an interpretation rather than attempting to find appropriate interpretations for parts of a string tokenized by space characters.

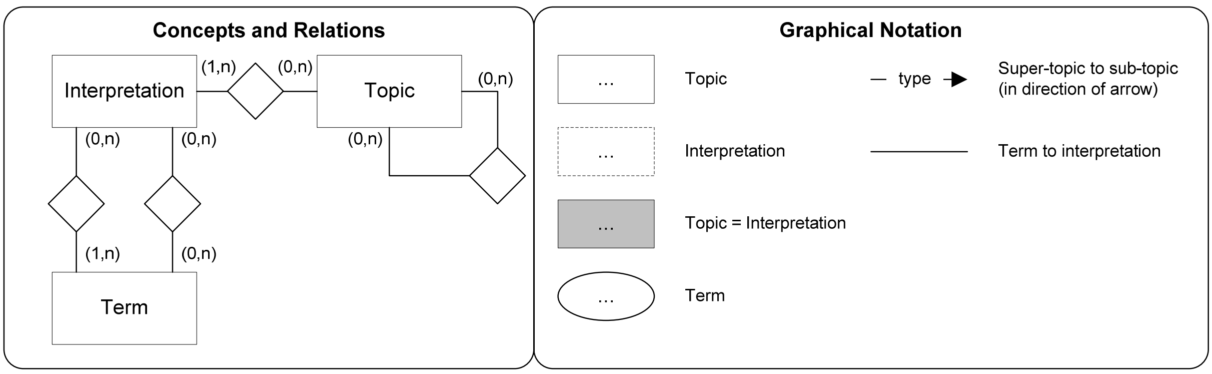

Figure 1. eTVSM ontology concepts, relations and graphical notation

Evaluations have 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 ontology see figure 4). In addition to the already introduced concepts a shortcut is introduced for cases in which topics and interpretations can not be separated reasonably.

2.2 Constructing concept vectors and concept similarities

Before eTVSM can calculate similarities between queries (represented as documents) and actual documents, vector-based representations and similarity matrices of ontology concepts – both topics and interpretations – have to be constructed. In the following we exemplary elaborate this procedure for topics and give a rough overview of the analogous steps to be carried out for interpretations.

In order to represent the structure of a topic map we can use a super-topic relation which represents a set of all direct parent topics of a topic τ_i:

$$S(\tau_i) \subseteq (\theta \setminus \tau_i)$$

Being t the number of topics in a topic map, a set of all topics is given by:

$$\theta = \{\tau_1, \tau_2, \ldots, \tau_t\}$$

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:

$$\begin{aligned} S^p(\tau_i) &= S(\tau_i) && \textit{for} \quad p = 1 \\ S^p(\tau_i) &= \bigcup_{\tau_k \in S^{p-1}(\tau_i)} S(\tau_k) && \textit{for} \quad p > 1 \end{aligned}$$

To obtain all super-topics of a target topic we can use an unbound transitive super-topic relation:

$$S^*(\tau_i) = S^1(\tau_i) \cup S^2(\tau_i) \cup S^3(\tau_i) \cup \ldots$$

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:

$$\theta_L = \{\tau_i \in \theta : \neg \exists \tau_k \in \theta \ \textit{with} \ \tau_i \in S(\tau_k)\}$$

Complementary to θ_L is a set of internal topic nodes θ_N which comprises 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:

$$\forall \tau_i \in \theta_L : \tau_i = \left|\left(\tau^*_{i,1}, \tau^*_{i,2}, \ldots, \tau^*_{i,t}\right)\right| \ \textit{with} \ \tau^*_{i,k} = \begin{cases} 1 \ \textit{if} \ \tau_k \in S^*(\tau_i) \vee i = k \\ 0 \ \textit{else} \end{cases}$$

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 the set θ_N can be constructed. As an internal topic is a generalization of its direct children internal topic vectors can be obtained as the sum of the topic vectors of their direct children. These topic vectors are again normalized to the length of 1.

Once we have obtained all topic vectors we can calculate the pairwise similarity of two topics as the scalar product of their corresponding topic vectors. Because all topic vectors are normalized, the scalar product is equal to the cosine of the angle β_{ij} between two topic vectors:

$$sim(\tau_i, \tau_j) = \tau_i \tau_j = \sum_{k=1}^{t} \tau_{i,k} \tau_{j,k} = \cos \beta_{ij}$$

After having constructed topic vectors and a matrix for their pairwise similarities, analogous steps have to be carried out for interpretations. Interpretation vectors are the normalized and weighted sum of the topic vectors of all topics related to an interpretation. The matrix of pairwise similarities is again calculated as the scalar product of these interpretation vectors and equals to the cosine of the angle between the two vectors (for a detailed explanation of this procedures see Kuropka 2004 or Polyvyanyy & Kuropka 2007).

2.3 Calculating document similarities

To calculate document similarities an eTVSM system scans queries and documents for terms present in the provided ontology and adds the corresponding interpretations to a so-called document vector. A document vector represents a document $d_j \in D$ (D is a set of documents) in a vector space:

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

Here, ω_{d_j, ϕ_i} is the weight of the interpretation ϕ_i in document d_j which might be a simple occurrence count within the document.

The document vector is the weighted sum of the interpretation vectors of the interpretations (which are identified via their corresponding terms) present in the document. Document vectors are normalized to the length of 1. The document vector length is obtained as:

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

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

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

2.4 First evaluations

Due to a lack of actual test data we performed our evaluations with the Times test collection (http://www.dcs.gla.ac.uk/idom/ir_resources/test_collections/time/) containing articles of the Times Magazine from the period of the Cold War. Figure 2 illustrates the results as superposed plots showing precision and recall for different ontology configurations (for details we once again refer to Polyvyanyy & Kuropka 2007). “VSM” is an ontology configuration simulating the standard Vector Space Model; i.e. all ontology concepts are modelled as being independent. “syn eTVSM” is a configuration which resolves synonyms using the general purpose WordNet (http://wordnet.princeton.edu/) ontology. "s-a eTVSM" is a semi-automatic configuration which uses the WordNet ontology as a starting point but also includes manually defined domain-specific concepts (from the period of the Cold War). Finally, to ease comparison with the state-of-the-art "LSI approx" shows the results from Bast and Majumdar (2005) for the Latent Semantic Index (LSI) model. The evaluations show that eTVSM, with a proper ontology, can outperform the classic Vector Space Model and the state-of-the-art Latent Semantic Index model.

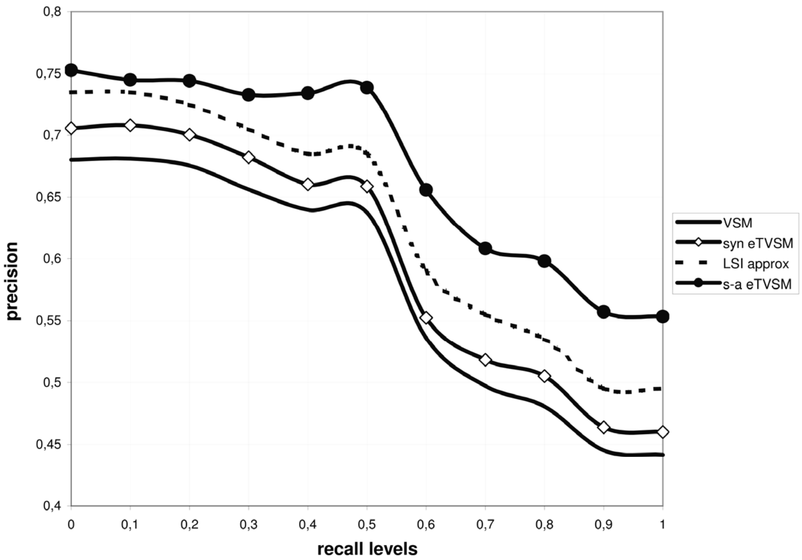

Figure 2. Precision at standard recall levels plots

3 CONSTRUCTING AN ONTOLOGY FOR AN ETVSM-BASED SERVICE DISCOVERY

As it becomes clear from the above discussion, a proper domain ontology is needed to fully realize the potential of eTVSM. Many approaches to ontology design have been proposed (e.g. Ushold 1996, Holsapple & Joshi 2002). We decided to choose 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 a 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 an expressive 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. 2005b) 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 are not addressed. The E3Service Ontology comprises well-accepted concepts from marketing research and provides valuable inputs in this respect; but technical aspects 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 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.

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.

Our ontology is centred on the concept of service (see figure 4). We understand services as economic activities that result in mostly intangible outcomes or benefits and are carried out on behalf of someone else (for a discussion of different definitions see for example Baida & Gordijn & Omelayenko 2004). The key to an effective description of a service is an unambiguous description of its capability (i.e. what the service does/offers). 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 capability is essential. The concept of capability can be interpreted as a kind of customer need for which a service offers a solution. This enables us to model different services which offer the same capability (e.g. the capability "listen to music" can be fulfilled by the services "Music Flatrate" or "Radio"). Thus a potential customer can search for an undefined service satisfying his needs without already considering a solution approach or concrete service offering.

For service discovery in the context of product-service bundles the relation between service and physical product can be of valuable help. Therefore we introduced the concept product which enables customers 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).

Based on their capabilities services can be assigned to standardized categorization schemes or taxonomies (e.g. UNSPSC, eCl@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. pre-sale, use, after-use) is often helpful.

Services are further described by properties. Due to the distinctive nature of services (e.g. intangibility, heterogeneity, 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 a number of non-functional properties. These non-functional properties exhibit constraints over the capability. This includes service quality (e.g. with respect to a standard or benchmark) and quantity (e.g. units to be delivered, frequency) as well as availability in terms of location (e.g. geographical region or virtual location like URI) and time (e.g. 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 (e.g. amount being charged for service provisioning), payment terms (e.g. the manner in which the consumer can pay the charged amount), delivery terms (e.g. the manner in which the service result is delivered to the customer) and contract duration (e.g. subscription time).

Orientation	Group	Concept \ Approach	Conceptual model of product-oriented services (Emmrich 2005)	E3Service ontology (Baida et al. 2005, 2006)	PAS 1018 (DIN 2002)	Taxonomy of non-functional service properties (O'Sullivan 2006)	OWL-S (Martin et al. 2004)	WSMO (Bruijn et al. 2005b)	Comment
Business-oriented	Function and Structure	Service	X	X	X	X	X	X	
		(Physical) Product	X		X			X[1]	1) link to related physical products
		Structure and Classification	X[1]	X[2]	X[3]	X	X[3]	X[3]	1) product life cycle 2) service bundles 3) taxonomies (e.g. UNSPC, eCl@ss)
		Function / Capability	X	X	X	X	X	X	
	Properties	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	
	Conditions	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	
		Ressources	X		X	X			
		References			X	X			
		Ratings			X	X			
		Certifications			X	X			
		Intellectual property			X	X			
	Interfaces	Organizational interfaces			X				
Information Systems-oriented	Interfaces	Technical interfaces			X[1]		X[2]	X[2]	1) technical interfaces (e.g. connector plugs) 2) software interfaces (e.g. WSDL)
	Functionality	Operations					X	X	
		Inputs					X	X	
		Outputs					X	X	
		Pre-Conditions					X	X	
		Post-Conditions / Effect					X	X	
		Composition					X	X	
	Realization	URI				X	X	X	
		Protocolls					X	X	
		Message formats					X	X	
		Other technical specifications					X	X	

Table 1. Comparison of analyzed approaches to service description

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 as well as single services 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 resources (e.g. personnel, know-how, experience, special equipment), references (e.g. project examples, success stories), ratings or rankings (e.g. independent benchmarks), certifications (e.g. adherence to security or privacy standards), and intellectual property rights (e.g. patents, copyrights, trademarks) are common means to express such qualifications.

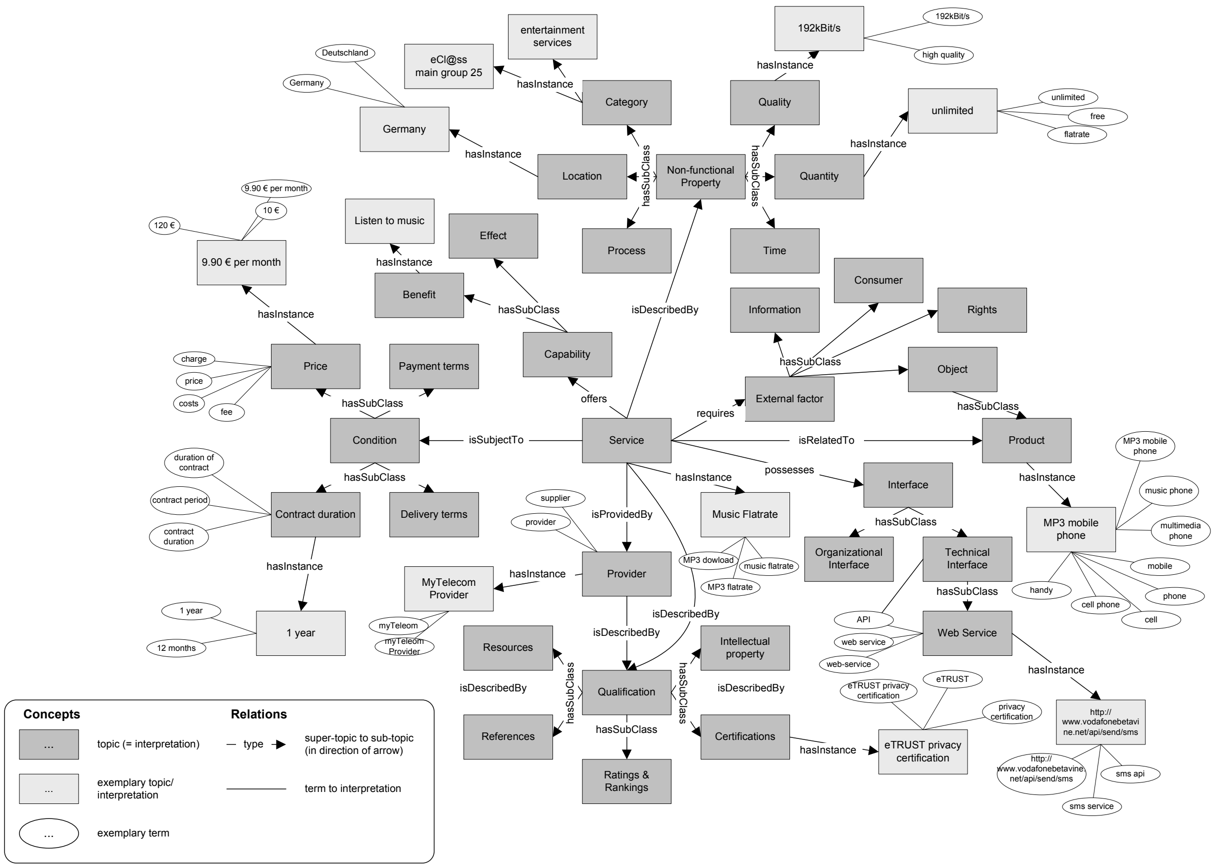

Figure 4. Ontology for product-service bundles (including exemplary instances and terms)

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 (e.g. how the service should be performed), rights (e.g. permissions in regard to the environment in which the service is performed) or a physical object (e.g. product or resource). 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. boolean search) is the higher quality of search results due to the consideration of semantic relations between 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 formal languages. To deliver these benefits eTVSM needs a domain ontology on which it can operate. We have presented a draft of such an ontology for the services domain, which we have developed based on an analysis and synthesis of both business-oriented and information systems-oriented literature.

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 and generate instance data we will continuously gather and analyze the vocabulary of the domain and actual service descriptions. 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 establish 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 VSM and LSI have already been performed. However further evaluation of effectiveness, efficiency, and usability, especially compared to semantic approaches using formal languages and compared to simple boolean search, for both eTVSM and the ontology itself is needed.

Parallel to these activities we are currently working on the integration of eTVSM – which is published under the General Public License (GPL) and available for download (http://code.google.com/p/ir-themis/) – into the central registry of a service oriented architecture (SOA) prototype for the flexible and efficient provisioning of product-service bundles within inter-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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References

Allmendinger, G. and Lombreglia, R. (2005): Four Strategies for the Age of Smart Services. Harvard Business Review, Vol. 83 Issue 10, 131-145.

Baida, Z. (2006). Software-aided Service Bundling: Intelligent Methods & Tools for Graphical Service Modelling. PhD thesis, Vrije Universiteit Amsterdam.

Baida, Z. and Gordijn, J. and Akkermans, H. and Saele, H. and Morch, A. Z. (2005). Finding e-Service Offerings by Computer-Supported Customer Need Reasoning. International Journal of E-Business Research, 1(2), 91-112.

Baida, Z. and Gorijn, J. and Omelayenko, B. (2004): A shared service terminology for online service provisioning. In Proceeedings of the Sixth International Conference on Electronic Commerce, Delft, 1-10.

Bast, H. and Majumdar, D. (2005): Why spectral retrieval works. SIGIR Forum, 11-18.

Bechhofer, S. and van Harmelen, F. and Hendler, J. and Horrocks, I. and McGuinness, D. L. and Patel-Schneider, P. F. and Stein, L. A. and Dean, M. and Schreiber, G. (2004). OWL Web Ontology Language Reference. W3C Recommendation.

Berners-Lee, T. and Hendler J. and Lassila O. (2001). The Semantic Web. A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities. Scientific American, http://www.sciam.com/print_version.cfm?articleID=00048144-10D2-1C70-84A9809EC588EF21

Bruijn, J. and Bussler, C. and Domingue, J. and Fensel, D. and Hepp, M. and Keller, U. and Kifer M. and König-Ries, B. and Kopecky, J. and Lara, R. and Lausen, H. and Oren, E. and Polleres, A. and Roman, D. and Scicluna, J. and Stollberg, M. (2005b). Web Service Modeling Ontology (WSMO). World Wide Web Consortium (W3C), http://www.w3.org/Submission/WSMO/

Bruijn, J. and Lausen, H. and Krummenacher, R. and Polleres, A. and Predoiu, L. and Kifer, M. and Fensel, D. (2005a). The Web Service Modeling Language (WSML). WSML Final Draft. Digital Enterprise Research Institute (DERI), http://www.wsmo.org/TR/d16/d16.1/v0.21/

Deutsches Institut für Normung (DIN) (2002). PAS 1018. Grundstruktur für die Beschreibung von Dienstleistungen in der Ausschreibungsphase. Beuth Verlag, Berlin, Wien, Zürich.

Emmrich, A. (2005). Ein Beitrag zur systematischen Entwicklung produktorientierter Dienstleistungen. HNI-Verlagsschriftenreihe, Nr. 170, Paderborn.

Garofalakis J. and Panagis, Y. and Sakkopoulos, E. and Tsakalidis, A. (2006). Contemporary Web Service Discovery Mechanisms. Journal of Web Engineering, Vol. 5, No. 3, 265-290.

Gruber, T. R. (1993). Toward Principles for the Design of Ontologies Used for Knoweldge Sharing. International Journal of Human-Computer Studies, (43), 907-928.

Hagemann, S. and Letz, C. and Vossen, G. (2007). Web Service Discovery - Reality Check 2.0. Working Papers of the European Research Center of Information Systems, No. 5, Münster.

Holsapple, C. W. and Joshi, K. D. (2002). A Collaborative Approach to Ontology Design. In Communications of the ACM, Vol. 45, No. 2, 42-47.

Kuropka, D. (2004). Modelle zur Repräsentation natürlichsprachlicher Dokumente - Information-Filtering und -Retrieval mit relationalen Datenbanken. Logos Verlag, Berlin.

Lay, G. (2006). Produktbegleitende Dienstleistungen in Industriebetrieben - Herausforderungen und Lösungsansätze. In Moderne Dienstleistungen - Impulse für Innovation, Wachstum und Beschäftigung. Beiträge der 6. Dienstleistungstagung des BMBF (Strech, D. and Wahlm D. Ed.), pp. 387-395, Campus Verlag, Frankfurt a.M.

Lindstone, H. and Turoff, M. (1975). The Delphi Method: Technology and Applications. Addison-Wesley, Reading.

Martin, D. and Burstein, M. and Hobbs, J. and Lassila, O. and McIlraith, S. and Paolucci, M. and Parsia, B. and Payne, T. and Sirin, E. and Srinivasan, N. and Sycara, K. (2004). OWL-S: Semantic Markup for Web Services. World Wide Web Consortium (W3C), http://www.w3.org/Submission/OWL-S/

O'Sullivan, J. (2006). Towards a Precise Understanding of Service Properties. PhD thesis, Queensland University of Technology.
Oliver Wyman (2003). Oliver Wyman-Analyse: Service im Maschinenbau - Ungenutzte Chancen im Servicegeschäft. Presseinformation vom 5.Dezember 2003, http://www.oliverwyman.com/de/pdf_files/PM_Downstream_digital.pdf
Organization for the Advancement of Structured Information Standards (OASIS) (2004). Introduction to UDDI. Important Features and Functional Concepts. Organization for the Advancement of Structured Information Standards (OASIS), http://uddi.org/pubs/uddi-tech-wp.pdf
Pal, N. and Zimmerie, R. (2005). Service innovation: A framework for success. eBRC White Paper, Pennsylvania State University.
Polyvyanyy, A. and Kuropka, D. (2007). A quantitative evaluation of the enhanced topic-based vector space model. Technical report, University of Potsdam.
Rai, A. and Sambamurthy, V. (2006). Editorial Note - The Growth of Interest in Services Management: Opportunities for Information Systems Scholars. Information Systems Research, 17 (4), 327-331.
Salton, G. and McGill, M. J. (1987). Information Retrieval. Grundlegendes für Informationswissenschaftler. McGraw-Hill, Hamburg.
Salton, G. and Wong, A. and Yang, C.S. (1975). A vector space model for automatic indexing. Communications of the ACM, 18 (11), 613–620.
Siorpaes, K. and Hepp, M. (2007). myOntology: The Marriage of Ontology Engineering and Collective Intelligence. Proceedings of the ESWC 2007 Workshop "Bridging the Gap between Semantic Web and Web 2.0, Innsbruck.
Statistisches Bundesamt (2003). Die Bedeutung einer wettbewerbsfähigen Industrie für die Entwicklung des Dienstleistungssektors - Eine Analyse der Bestimmungsgründe der Expansion industrienaher Dienstleistungen in modernen Industriestaaten. http://www.bmwi.de/BMWi/Navigation/Service/publikationen,did=31812.html
Sturm, F. and Bading, A. and Schubert, M. (2007). Investitionsgüterhersteller auf dem Weg zum Lösungsanbieter - Eine empirische Studie. Institut für Arbeitswissenschaft und Technologiemanagement. Fraunhofer IRB Verlag, Stuttgart.
Ushold, M. (1996). Building Ontologies: Towards a Unified Methodology. In Proceedings of Expert Systems '96, Cambridge, 1-18.
Vargo, S. L. and Lusch R. F. (2008). Service-dominant logic: continuing the evolution. Journal of the Academy of Marketing Science, 36 (1), 1-10.