Smart Product Description Object (SPDO)

Sabine JANZEN [1], Wolfgang MAASS
Hochschule Furtwangen University (HFU), Germany

Abstract. Smart products connect the drafts of physical products and information goods and allow the embedding of digital product information into physical products. This concept demands specific knowledge representations, especially digital product information. After consideration of several standardized product descriptions, we present the Smart Product Description Object (SPDO), a generic data model for describing smart products formalized by semantic representations (OWL-DL), which enables a product-centered communication between customers and products within physical environments.

Keywords. Digital product description, NLP, OWL, DOLCE, ontology

Introduction

Through the increasing informational complexity of consumer products, the communication needs of customers regarding the products at the point of sale rise intensely. Products possess a lot of different information, such as product descriptions, service and support features or user generated or professional reviews, and are linked to compatible or alterative products. For satisfying the communication needs of the consumer against this information overflow, natural language based communication services should be embedded directly into the product, resuming the idea of Ubiquitous Computing [1]. This concept enables a communication between users and physical products [2]. As physical products, we describe goods, e.g. a jacket that can be touched by a customer within a physical environment, for instance a fashion store. The linkage of physical products with communicative functions requires the integration of value-added mobile services and digital product descriptions [2] and represents the concept of a smart product [3]. In order to realize natural language based communication within a physical environment, a smart product needs contextual information and a product-centered "memory" in form of specific knowledge representations. In this article we introduce the concept of a web-based semantic data model for the product mediated customer communication in physical retail environments. Therefore, we adopt a design science methodology [4]. Our results will be presented in the sense of a "proof by construction" [5].

[1] Sabine Janzen, Hochschule Furtwangen University (HFU), Robert-Gerwig-Platz 1, 78120 Furtwangen, Germany; E-mail: sabine.janzen@hs-furtwangen.de.

In Section 1 we discuss the requirements on digital product information in physical environments. In the following, we introduce the model of our specific digital product information that meets the defined requirements (Section 2). In Section 3, we exemplify the model in a shopping domain. Finally we discuss our current results and future work (Section 4).

1. Digital Product Information in Physical Environments

Products are physical goods that are described in a standardized and not standardized way. A product description constitutes conceptual descriptions of knowledge about products; it changes frequently and increases fast. Currently, the product descriptions exist in terms of static databases or XML structures. They are not publicly accessible and partially available only. Updates and extensions have to be inserted manually with great effort. In the course of the development, the product description standards BMEcat®, ETIM/eCl@ss and GS1 were considered.

A digital product description within the scenario of a communication between physical products and customers in physical environments has to fulfill specific requirements:

- **Logical semantic structure** - The digital product description needs a logical semantic structure for the automatic processing and extension of data. None of the considered product descriptions fulfills this requirement.
- **Linking of product descriptions** - The opportunity of combining product descriptions constitutes the precondition for enabling the communication between products and the dynamic linking of product bundles. The standard BMEcat® allocates this feature just partially in terms of the concept PRODUCT REFERENCE that allows cross references between articles of a catalogue or different catalogues [6].
- **Mapping of current standards** – To avoid the development of an isolated application, the product description has to be able to map external product standards. The standard BMEcat® provides no opportunity to accomplish such a transfer, but there are software tools with costs that implement that feature.
- **Distributed repositories** – Digital descriptions of smart products may not form a closed system; they are stored in web-based distributed repositories and provide diverse kinds of information. None of the considered product descriptions fulfills the requirement of a web-based distributed storage.
- **Natural Language Processing** – The more natural a communication with a product the higher is the acceptance of services and information [7], [8], [9]. The adaptiveness can partially be achieved by dialogue-centered communication based on Natural Language Technologies [3]. In line with the natural language communication between the customer and the product, the product description has to take the role of a non linguistic knowledge representation of a Question-and-Answer (QA) system. At the moment, QA-systems often hold unstructured information sources, such as provided by content management systems or search engines for the WWW [10]. The semantic logical structure of the web-based product description has to be

processible within the Natural Language Processing. None of the considered product descriptions fulfills this requirement.

- **Dynamic and automatic extension –** The opportunity to extend a digital product description dynamically and automatically allows the integration of contextual information about the physical environment or reasoned conclusions into the semantic description in real-time. The considered product description standards do not offer such a feature yet; updates and extensions have to be inserted manually with great effort.

None of the standardized product description standards - BMEcat®, ETIM/eCl@ss and GS1 - fulfills all the requirements as mentioned above. Therefore, the concept of a product mediated communication between customer and product in physical environments demands the development of a specific semantic product description.

2. Smart Product Description Object

Smart products are characterised by the following attributes: they are (1) situated, (2) personalised, (3) adaptive, (4) pro-active, (5) business-aware and (6) network capable (7) [3]. They can be described by a specific semantic product description, called Smart Product Description Object (SPDO) [2]. The SPDO constitutes an instantiated sub class of the DOLCE Information Object [11]. We have assigned the attributes introduced before to a set of five information types, called facets: (1) Product description, (2) Presentation description, (3) Community description, (4) Business description and (5) Trust&Security description.

The five facets compose the container model of the SPDO; each of them consists of several sub facets. Within the product description facet the smart product is categorized in form of product categorization standards, e.g. GS1. Any information that is linked inseparably with the product, for instance its material, is represented. Furthermore, externalized information of the product, e.g. product reviews by online communities, is stored. The business description facet contains information of contracts whose subject the physical product is. Within this facet diverse price schemata can be defined that enable the implementation of dynamic pricing strategies. In addition, the form of the negotiations during the buying process is described, e.g. the sale at auction. The community description facet specifies the situation in which the physical product can be used concerning the actors, roles, obligations etc. in form of a description. In the context of a usage history the real usage situations of the product are stored; based on this a product memory is build up. Inside of a shopping situation, a product is presented

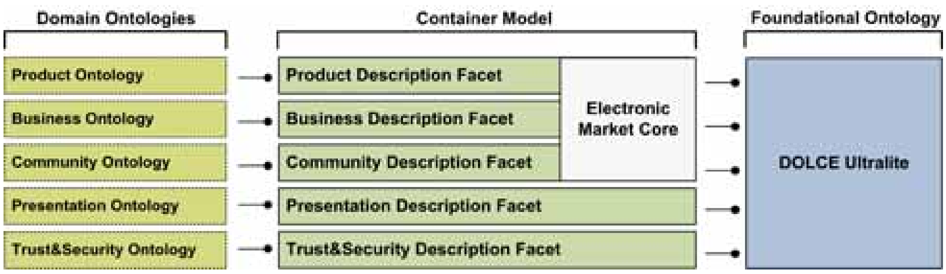

Figure 1. Smart Product Description Object

in several modalities; the presentation description facet covers all information of the presentation of the product within the physical environment, for instance via light. Based on the trust&security description facet the digital rights management and access control of the SPDO can be arranged.

In addition to the container model described above, the SPDO consists of three additional parts: the foundational ontology represented by DOLCE Ultralite[2] (DUL) [12], the domain ontologies and the Electronic Market Core (EMC) (cf. Figure 1). The statements of the container model are anchored in the foundational ontology and therefore based on the description and situation (DnS) approach of DUL [12]. We dispose partitions of the concepts of DUL directly and in form of super classes for classification of the specific classes of the SPDO, respectively. The relations of DUL are customized to our needs by OWL restrictions. The integration of the SPDO concepts into the DOLCE ontology holds the following advantages: (1) DOLCE is a foundational ontology with a broad distribution. An ontology based on DOLCE constitutes an open and portable system. (2) The SPDO statements are anchored in concepts of the common sense. Hence, communication services within physical products dispose of sense of the world and are able to act intelligently. (3) The processing of the DnS approach poses the basis for reasoning about the DOLCE structure.

The container model and the foundational ontology contain information that is generic and independent from the product domain. However, the domain ontologies extend the facets of the container model with domain specific data of the physical product.

The Electronic Market Core is a general ontological framework for electronic markets that provides machine processable terms in order to be handled by market services [11]. The conceptual model is based on the foundational ontology DOLCE and anchored in the SPDO (cf. Figure 1). The EMC aligns the market concepts, e.g. buyer, seller or money, with the ontological concepts of DOLCE according to the DnS approach [11].

On the implementation level, each part of the SPDO is formalized by semantic representations, currently in OWL-DL[3]. Furthermore, we use a SPARQL-based request protocol [13].

The SPDO fulfills all the requirements of product mediated communication in physical environments as mentioned in Section 1. It possesses a *logical semantic structure* for the automatic processing and extension of data in terms of OWL-DL. The SPDOs of several products can be *linked dynamically* based on the SPDO structure itself or the appliance of rules. This enables the communication between products and the dynamic composition of product bundles. Our dynamic product information does not constitute an isolated application; it allows the *transfer of standardized product information* into the SPDO and vice versa, e.g. BMEcat®. Furthermore, the SPDO is *stored in web-based distributed repositories.* In line with the natural language communication between the customer and the product, our product description is able to take the role of a *non-linguistic knowledge representation* of a QA system. Based on the appliance of rules, the semantic product data of the SPDO are *extended dynamically and automatically*.

[2] http://wiki.loa-cnr.it/index.php/LoaWiki:DOLCE-UltraLite
[3] http://www.w3.org/TR/owl-features/

3. Application in Physical Environments

We applied our dynamic product information to diverse physical product domains, for instance fashion and consumer electronics. In the fashion shopping scenario all fashion products are described by SPDO instantiations [14]. The information about the SPDO is processed by the Tip ‘n Tell middleware [3].

In conjunction with studies, we defined several rules that are applied to the SPDO instantiations of the fashion products. The rule knowledge is represented by standardized web-based rule languages, current Jena rules (Jena 2 framework)[4] [14]. The combination of the rule system with the semantically annotated descriptions of the SPDO in OWL-DL format enables the implementation of services that allow the detection of similar and compatible products [14], e.g. two fashion products are similar if both have the color of a particular color class. When the rules are applied to the semantic product information, the data of the SPDO are dynamically extended by the results of the achievement of the rule. The shoppers are equipped with a RFID capable mobile device (e.g. PDA); the smart products are annotated with RFID tags, which carry URIs to the location where a product’s SPDO is stored [3]. The mobile Tip ’n Tell client enables the communication between the customer and the product within the physical environment. Thus, the consumer is able to interact with the product and ask natural language questions. In order to realize this, Tip ‘n Tell disposes of a natural language processing module applied as QA–system in form of a web service. The knowledge base of the QA-system consists of a non-linguistic part – the SPDO – and a linguistic part consisting of an ontology (OWL-DL). The customer communicates with the product by composing a question segmentally. The question is sent in form of a request to the NLP web service. After processing the question, the QA-system starts the schema based generation of the answer requesting the linguistic knowledge base via SPARQL. When the linguistic skeleton of the answer is completed, part-of-speech tags remain that hold references to non-linguistic product information. The QA-system fills the tags with information requested from the SPDO of one or more products based on SPARQL and sends back the final answer to the mobile client.

With the SPDO, the QA-system holds a structured information source that can be processed in real-time and stored web-based in distributed repositories. The logical semantic structure offers advantageous opportunities for the mapping of schema based natural language compositions and their combining with lexical items [15].

4. Conclusion and Future Work

The natural language communication between customers and products in physical environments places specific demands on digital product information. We presented the Smart Product Description Object (SPDO) as a digital product description that fulfills those requirements (cf. Section 1). The SPDO is a generic data model for describing smart products. Beside the usage of the semantic product description as non-linguistic knowledge base within the natural language communication, the relation between SPDO instantiations and rule sets as well as the automatic activation of rules by SPDO instances according to situational changes are key issues [14] (cf. Section 2). We tested

[4] http://jena.sourceforge.net/inference/

and extended our product description to various domains, e.g. fashion, within the Tip ’n Tell middleware (cf. Section 3).

Our current SPDO version is quite stable, but suffers from inconsistencies within the ontology deployment environment. Furthermore, we prefer the appliance of SWRL[5] as a standardized web-based rule language to the SPDO data. However, currently we use Jena rules, because there is no integration of SWRL into the Jena 2.0 middleware which we use as the basis of Tip ‘n Tell. In addition to that, the SPARQL requests in line with the natural language processing achieve an immense complexity that affects the flexibility of operating on the semantic data.

In the future, we will focus on three issues: (1) The reasoning of the underlying DOLCE ontology to gain product knowledge regarding the common sense, for instance the general structure of shopping situations, (2) the integration of reasoning results into the natural language processing, e.g. the common course of a sales conversation and (3) the appliance and testing of the SPDO during a complete product life cycle with several situations such as buying and support.

References

[1] M. Weiser, "The Computer of the 21st Century", ACM SIGMOBILE Mobile Computing and Communications Review, vol. 3, no. 3, pp. 3–11.

[2] W. Maass, and A. Filler, "Towards an Infrastructure for Semantically Annotated Physical Products", in Informatik 2006 - Informatik für Menschen: Conference Proceedings, Gesellschaft für Informatik e.V., Ed., 2006.

[3] W. Maass, and S. Janzen, "Dynamic Product Interfaces: A Key Element for Ambient Shopping Environments", in 20th Bled eConference - Conference Proceedings: "eMergence: Merging and Emerging Technologies, Processes, and Institutions" (June 3- 6, 2007), M.L. Markus, J.F. Hampe, J. Gricar, A. Pucihar, and G. Lenart, Eds., Bled, Slovenia, 2007.

[4] A.R. Hevner, S.T. March, J. Park, and S. Ram, "Design Science in Information Systems Research", MIS Quarterly, vol. 28, no. 1, pp. 75–105.

[5] J.F. Nunamaker Jr., M. Chen, and T.D. M. Purdin, "Systems Development in Information Systems Research", Journal of Management Information Systems, vol. 7, no. 3, pp. 89–106.

[6] BME e.V., Spezifikation BMEcat® 2005, 2005, [2008 Aug 01], Available at http://www.bmecat.org.

[7] X. Bo, and I. Benbasat, "E-Commerce Product Recommendation Agents: Use, Characteristics, and Impact", MIS Quarterly, vol. 31, no. 1, pp. 137–209.

[8] Y.H. Cho, J.K. Kim, and S.H. Kim, "A personalized recommender system based on Web usage mining and decision tree induction", Expert Systems with Applications, vol. 23, no. 3, pp. 329–342.

[9] G. Häubl, and V. Trifts, "Consumer Decision Making in Online Shopping Environments: The Effects of Interactive Decision Aids", Marketing Science, vol. 19, no. 1, pp. 4–21.

[10] E. Voorhees, "Overview of the TREC 2002 Question Answering Track", in Proceedings of the Eleventh Text REtrieval Conference, Text REtrieval Conference (TREC), Ed., 2002.

[11] W. Maass, W. Behrendt, and A. Gangemi, "Trading digital information goods based on semantic technologies", Journal of Theoretical and Applied Electronic Commerce Research, vol. 2, no. 3, pp. 18–35.

[12] C. Masolo, S. Borgo, N. Guarino, and A. Oltramari, TheWonderWeb Library of Foundational Ontologies: Technical Report D17, 2003.

[13] E. Prud'Hommeaux, and A. Seaborne, SPARQL Query Language for RDF, 2007.

[14] W. Maass, A. Filler, and S. Janzen, "Reasoning on Smart Products in Consumer Good Domains", in Workshop AmI Blocks at the European Conference on Ambient Intelligence (AmI-07): Proceedings, Darmstadt, 2007.

[15] S. Janzen, "Product-centered communication in natural language within shopping situations", master's thesis, Furtwangen University, 2008.

[5] Semantic Web Rule Language - http://www.w3.org/Submission/SWRL/