Towards an Infrastructure for Semantically Annotated Physical Products

Wolfgang Maass, Andreas Filler

Hochschule Furtwangen University
Robert-Gerwig-Platz 1
78120 Furtwangen, Germany
firstname.lastname@hs-furtwangen.de

Abstract: Small-scale wireless communication technologies allow for situated consumer-product communication during buying decision making. We present the status of a generic model and implementation of semantically annotated physical products and an associated mobile and web-based infrastructure. Cornerstones are a RDF-based container model for semantic product descriptions (*SPDO*), an appropriate web-based product query language (*PQL*) and a web-service middleware infrastructure (*Tip 'n Tell*).[1]

1 Introduction

With area-wide introduction of RFID and similar technologies, physical and digital environments can be realised on fine-grained business levels [FM05]. This initiates potentials for the support of business processes, in particular within the domain of supply chain management [BP05]. But few attempts have been made to discuss potential business impacts at the point-of-sale (PoS) at the interface between buyers and producers [Löb05, WW06].

Marketing research distinguishes between cognitive and affective information [AF80]. Consumers derive functional attributes from product information that are evaluated regarding their potential utility [OR83]. Interactive communication functions are embedded into products, which adapt to customer needs and situational cues [WW06].

The basis of such product communication functions are on one hand dialogue systems and on the other hand semantic product representations. Within a shopping context, a key question is how product presentations can be enhanced by situated product presentations on the spot of buying decision making. More specifically: (1) How can physical products be semantically self-described? and (2) How can physical products be integrated with web-based digital product information spaces?

In this article we will present (section 2) a product description framework for physical

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products (Semantic Product Description Object - SPDO) and a corresponding middleware architecture, called *Tip 'n Tell*, (section 3). In section 4 related work is described. Finally, results are summarised and an outlook is given (section 5).

2 Semantically annotated product descriptions

By embedding digital communication facilities into physical product instances paves the ground for merging digital and physical environments and thus generating the new product category of hybrid products. Hybrid products are a container concept for any kind of products that are materialised by mental, digital or physical products and maintain connections to *product descriptions* ([MB06]. Product descriptions are conceptual descriptions of information and knowledge about products. *Product category descriptions* are defined by reification of product descriptions. Product categories are conceptualisations - therefore called *product category descriptions* - that are specialised by product descriptions.

For instance, a buckle in the right door of a particular Golf III is added to a product description but not to the product category description. Though, physical products are realisations of product category descriptions which are described by product descriptions. product descriptions can be realised by appropriate *digital product descriptions* that are used on application level of information technological systems.

With these terms, *Smart Products* can be described as physically realised products that are specialisations of product categories attached with digital product descriptions. Smart Products are characterised by the following attributes (similar to key characteristics of Ambient Intelligence [Wah03]): (1) situated, (2) personalised, (3) adaptive, (4) pro-active, (5) business-aware and (6) network capable.

These characteristics of Smart Products require semantic representations that can be leveraged on functional level in network environments. Based on experience with digital products descriptions for digital goods [MB06], we have developed a container model for Smart Products, called *Semantic Product Description Object* (SPDO). The SPDO concept is intended to provide a structure on the computational level that is analogue to object-centered conceptualisations of products. From the ontological viewpoint given by the foundational ontology DOLCE+ [MBGO03], a SPDO is conceptualised as a specialisation of an *information object*.

A SPDO structure consisting of six facets and sub-facets (derived from [MB06]):

1. *product description*: Connection to established product meta data standards and propositional description of the functional properties of a product on an abstract level.

2. *presentation description*: Description of how the product description is presented to users

3. *community description*: Description of plans, tasks, roles and goals in the context of a community

4. *business description*: negotiation protocol, pricing scheme and contract information
5. *trust & security*: reputation information and access control
6. *self-description*: specification of the SPDO in machine understandable form.

In the following, we will focus on the *product description facet* that is modelled by *P-RDF*.

3 Technical Infrastructure for Smart Products

3.1 RDF-based Product Query Language

P-RDF is a RDF-based [KC04] product description language based on product category specific ontologies that is designed for capturing product information required by buyers within buying decision making situations [KR92]. For P-RDF, we have developped a product query language, *PQL* [Fil06], that allows web-based retrieval of propositional product information stored in P-RDF. Similar to SPARQL, PQL is a high-level query language that is designed to support schematic natural language processing applications [McK85].

A *PQL query* allows to retrieve fixed product values and relations of other products in RDF triple format. In our domain, those products can be accessories, price information, standard definitions or manufacturer references. Restriction and selection mechanism are available just as well. A PQL query locally and remotely stored digital product descriptions.

```
compatibleWithProduct GET INSTANCES GET "Name"
```

```
<PQLresults>
   <PQLresult PQLtype="Name" PQLValue="Comp product name A" />
   <PQLresult PQLtype="Name" PQLValue="Comp product name B" />
</PQLresults>
```

In this example, the PQL query delivers the names of all products which are defined as compatible with a particular product.

3.2 Web-based Middleware

The scenario that is considered is a consumer electronic shop. Buyers are equipped with a PDA (HP iPAQ Pocket PC) and a RFID-pen (Cathexis IDBlue(TM) RFID Pen). A cellular phone with integrated RFID reader is conceivable as well (E.g. Nokia 3220 [Com04]). Products (used domain: MP3 players) are tagged with RFID chips which carry references to SPDO stores while the PDA is connected to the Internet via WLAN.

The whole infrastructure, called *Tip 'n Tell*, encompasses a *Tip 'n Tell web service* and various RDF-based SPDO stores (see figure 1). The *Tip 'n Tell* web service is realised in C# and collects SPDOs and in particular P-RDF data from SPDO stores on PQL requests.

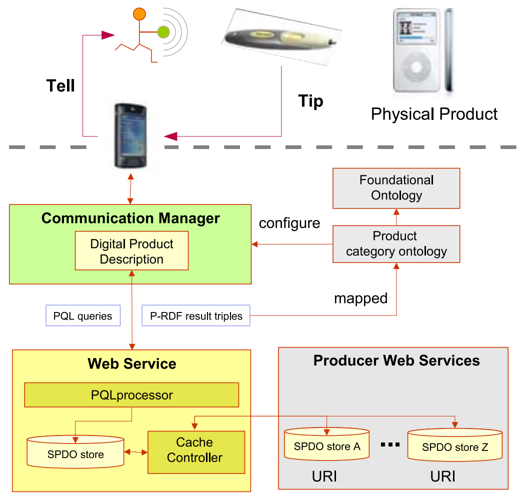

Figure 1: Abstracted *Tip ’n Tell* Architecture

The service also contains a cache controller to ensure data integrity at repeating and interrelated queryies. A RDF library called *SemWeb* [Tau06] is used for management of RDF data within the .NET environment.

The current use case is that a buyer touches a RFID-tagged product (MP3 player) with a RFID-device, e.g., RFID pen, and receives a URL. This URL is send to the PDA that sends it to a *Tip ’n Tell* web service. A user session is created and the web service starts to receive the URL associated SPDO store. References inside the received SPDO store will be resolved by querying further SPDO stores. The data pool provided for the product is archived by the cache controller for further inquiries.

A *communication manager* provides a set of natural language question patterns that can be instantiated by SPDO information in combination with the initially retrieved PQL results (cf. [Gri06]). Via further PQL queries the buyer can explore product description presentation. In the current version schematic w-questions, e.g., what, where, who, are mapped onto product information carried by retrieved P-RDF descriptions [Gri06].

4 Related Work

Ubiquitous environments can be classified into (1) augmented reality, (2) intelligent environments and (3) distributed mobile systems [EBM05]. *Smart Products* and the *Tip ’n Tell* infrastructure belong to the class of intelligent environments. Under the umbrella of tangible user interfaces [UI01] several shopping assistent systems have been recently developed. The *Mobile ShoppingAssistent* (MSA) [WW06] supports dialogs between users and products while focussing on multimodal communication. Earlier systems, such as *MyGrocer* [KSRG02] and [FJHW00], venture the integration of physical objects and digital representations.

A similar approach for the interaction between users and single augmented objects has been followed in the *Reachmedia* project [FTS+05] that investigates the touch based interaction with objects based on command represented by gestures. Similarly, *Cooperative Artefacts* provide a communication and interaction framework [SGKK04].

These approaches use proprietary non-web-based knowledge representations and ad-hoc product ontologies. Therefore, these systems are not designed for heterogeneous and web-based product information infrastructures as targeted by the *Smart Product* concept and the *Tip 'n Tell* architecture. Nonetheless, our work is strongly influenced by these approaches.

5 Conclusion and Future Work

We have presented the status of our work on Smart Products and the corresponding mobile and web-based middleware architecture *Tip'n Tell*. The main contribution consists of a RDF-based container model for product description (SPDO), an appropriate web-based query language (PQL) and a web-service oriented middleware infrastructure (Tip 'n Tell).

The infrastructure has been tested for single products in a completely distributed web service environment by focussing on the product description facet. Other SPDO facets are not evaluated in our current test environment.

In future work we will focus on three issues: (1) realisation of the whole SPDO model, (2) integration of a schematic natural language dialogue generator based on SPDO and (3) empirical evaluation of Smart Products and their impact on consumer behavior.

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