Tip ‘n Tell: Product-Centered Mobile Reasoning Support for Tangible Shopping

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Abstract. Smart products are hybrids that merge tangible products with mobile information technologies. This opens up unprecedented opportunities for product designers and marketing manager for implementing adaptive and situation-aware product interfaces that generate dynamic communication behavior with customers during the whole life-cycle of a product. The realization of this vision requires, beside others, expressive and machine-readable product representations and an open product information infrastructure. With Tip ‘n Tell we present an architecture that supports smart products. Product information is represented by a coherent container model, called SPDO that uses semantically annotated descriptions in OWL-DL format. Based on these elements we demonstrate services that allow finding multimedia content that fits to a product in focus based on a combination of DL-reasoning and RDF-based rule derivations. Product similarity and compatibility is also determined by DL-reasoning on feature level.

Keywords. smart products, semantic technologies, electronic commerce, ambient intelligence

1 Introduction

Empirical studies indicate that consumer groups, such as shopping lovers and belonging seekers, would intend to use value-added shopping services in tangible shopping environments that provide, for instance, shopping alerts and product information [1]. Initial technological approaches show how interactive and adaptive communication functions support customer relationship and product design processes [2]. In this article, we present a concept, called *smart product* that virtually and physically merges the concepts of tangible products and information products. The concept of a *smart product* extends traditional views on products [3, 4] in the sense that they can adapt tangible products to usage contexts. For smart products we identified three core requirements [5]:

- (R1) adaptation to situational contexts,
- (R2) adaptation to actors that interact with products or product bundles, and
- (R3) adaptation to underlying business constraints.

We have implemented the smart product concept on the basis of a dedicated middleware, called Tip ‘n Tell, which is a technical infrastructure for value-added mobile services. It allows embedding of digital product information into tangible products and thus supporting product mediated communication between products and users [5, 6]. During the information phase of a shopping transaction, customers compare products and use supporting information, such as product reviews. Consumers search costs for both services are generally high because product information is hard to compare and only biased product information is provided by retailers. In this article we present how both services can be implemented by smart products based on machine-processible semantically annotated product information.

In section 2, we present the smart product concept and our application environment, called *Tip ‘n Tell*. Next we describe how semantic representations of smart products can be used for basic reasoning services, such as determination of supportive multimedia contents, product similarity, and product compatibility. In section 4 we briefly discuss related work before this article is finished with a summary and an outlook on future work.

2 Smart products and Tip ‘n Tell Architecture

Currently tangible products provide static textual and graphical information that either is directly attached to products, attached to product packings, or located nearby as stand-alone signboards. Information processing is left to the consumer. Our vision for *smart products* is that they automatically collect, process, and communicate any kind product information from any information source that can be accessed via digital networks [5, 6]. This includes product information from producers, retailers, third party content providers and online communities. Efficient product information processing requires formal representations of product-related and context-related information. Because product information changes rapidly and increases over time we have developed a data schema for smart products, called *Smart Product Description Object* (SPDO), that distinguishes six core product information types [6, 7]: (1) product description (PD), (2) presentation description (PRD), (3) community description (CD), (4) business description (BD), (5) trust&security description (TS) and (6) self description (SD).

Product information is retrieved from URI-referenced information sources and integrated into SPDOs by a *SPDO broker* web service (see **Fig. 1**). This allows the integration of product information at usage time which enables, for instance, instantaneous implementation of product communication and pricing strategies. The SPDO broker transfers product information in SPDO-format to a *dynamic product interface* that maintains the whole product-user communication [5]. Dynamic product interfaces are either implemented on mobile devices or directly into a tangible product by embedded systems. In the first case the concept of a smart product is implemented virtually. The whole *Tip ‘n Tell* architecture consists of web-based information sources, a SPDO-broker, dynamic product interfaces, and dedicated transfer protocols (for details see [5, 6]).

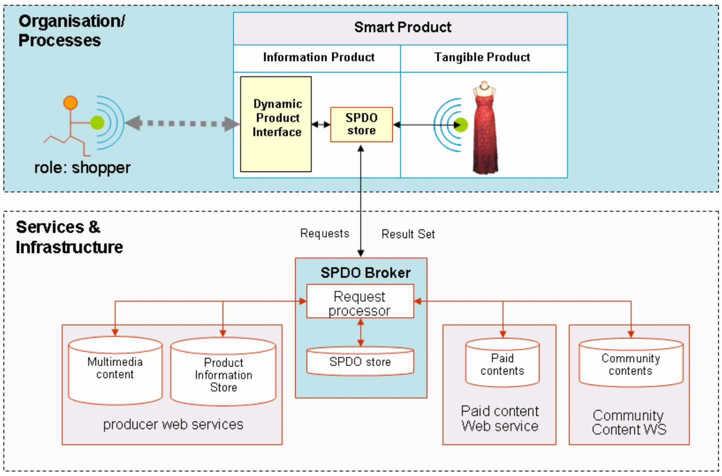

Fig. 1. Tip 'n Tell architecture

In our current implementation *Tip 'n Tell* shoppers are equipped with a PDA and a RFID-reader pen (Cathexis IDBlue RFID Pen) and smart products are annotated with RFID tags (ISO15693, HF - 13,56 MHz, proximity range) which carry URIs to the location where a product's SPDO is stored. The core of the SPDO broker is implemented on top of the Jena 2.0 system (jena.sourceforge.net) that provides a RDF storage used for the SPDO store and interfaces to reasoners. On mobile client side we use the .Net Compact Framework on PDAs (HP iPAQ Pocket PC).

3 Smart product services

In the following we present three services that support customers in shopping situations. First, we describe how semantically annotated multimedia contents are retrieved that fit to a particular product in focus. Then it is shown how information stored in SPDOs can be used for comparing products.

3.1 Supportive contents

Multimedia can positively influence customer's evaluations of products in online shopping situations [8] which leads to the hypothesis that multimedia contents also support buying decision making in mobile shopping situations [1]. Because multimedia contents can be provided by an unrestricted number of services, we use a matching approach that compares semantic annotations of products with semantic annotations of multimedia contents. Requirements for multimedia contents are carried by the SPDO's product description facet. They are described by facts (implemented by OWL statements) and rules (implemented by Jena2 rules).

For instance, the following rule determines that a multimedia content shall contain a least two distinct products. Because they are shown together it is entailed that both fashion products fit together (*FitsTo*). The information that both products are shown in this content it represented by the predicate *IsPromotedIn*.

```
[fitsTogether:
   (?a fcontent:productInShow ?b)
   (?a fcontent:productInShow ?c)
   (?b pre:isA ?d) (?c pre:isA ?e) notEqual(?d,?e)
->
   (?b pre:fitsTo ?c) (?c pre:fitsTo ?b)
   (?b mmd:isPromotedIn ?a) (?c mmd:isPromotedIn ?a)]
```

Consistency of a model is evaluated by a DL reasoner (here FACT++ [9]). Multimedia contents that fulfill related rules and lead to a consistent model are assumed to provide appropriate contents for a particular product. Appropriate multimedia contents are offered to a consumer via the dynamic product interface [5]. A consistent model is stored in the product description facet of a product for subsequent usage.

3.2 Similarity

Similarity measures for products are domain-dependent. They are either linear, e.g., prices, or non-linear, e.g. colors. Analogue to the model presented in the last section, similarities are computed based on semantic descriptions of product features and rules (for a statistical approach cf. [7]). For instance, color similarity is represented by a color scheme that distinguishes between *colors*, *color types* and a generic class, called *color*. The similarity rule for color is defined as follows:

```
[similarColor:
     (?a rdf:type pre:Product) (?a pre:hasColor ?c)
     (?c rdf:type ?d)(?d rdfs:subClassOf pre:Color)
     (?d rdfs:subClassOf ?e) notEqual(?e, pre:Color)
     (?b rdf:type pre:Product)(?b pre:hasColor ?f)
     (?f rdf:type ?g) (?g rdfs:subClassOf pre:Color)
     (?g rdfs:subClassOf ?h) notEqual(?h, pre:Color)
     notEqual(?a, ?b) equal(?e, ?h)
-> (?a pre:similarTo ?b) (?b pre:similarTo ?a)]
```

Similarity rules are defined for each product domain according to relevant feature dimensions. Again, similar products are communicated by dynamic product interfaces.

3.3 Compatibility

Beside similar products, customers search for fitting products and accessories. For brevity we present our approach by a fashion example. Style related descriptions of products are tested for logical consistency. For instance, we assume that product A is an instance of category "*knee_high_leather_boot*", product B is an instance of category "*cropped_jacket*" and product C is an instance of category "*miniskirt*". Furthermore it is defined in the knowledge base that the style of “*knee_high_leather_boot*” fits (*GoesStyleWith*) with “*cropped_jacket*” and “*miniskirt*”. With the following rule it can be inferred that also product B fits to product C:

```
[fitsTogether:
      (?a pre:isA ?c) (?b pre:isA ?d)(?c pre:fitsTo ?d)
      notEqual(?a,?b) notEqual(?c,?d)
->    (?a pre:fitsTo ?b) (?b pre:fitsTo ?a)]
```

By continuous application of this rule a undirected graph of all fitting products is generated. With this mechanism product descriptions from various product information services can be dynamically integrated, i.e. product bundles can be generated according to logical descriptions stated by rules.

4 Related work

The concept of a smart product enriches tangible products with a behavioral component, i.e. smart products adapt to situations and are communicative. Therefore the concept of a smart product has resemblances with more generic approaches such as *adaptive user interfaces* [10], *tangible user interfaces* [11], *augmented realities* [12] and *ambient computing* [13]. A more closely related approach is the Mobile ShoppingAssistent (MSA) that focuses on multimodal communications between a single product and individual users [14]. Earlier systems, such as MyGrocer [15] and [16], venture the integration of tangible objects and digital representations. Tip ‘n Tell extends these approaches by using web-based semantic representation technologies with distributed knowledge sources.

5 Conclusion

Ubiquitous computing technologies provide a means for embedding high-level information technologies into any kind of tangible product. This challenges producers to generate new product designs that leverage the possibility of communicative and adaptive high-cost but also low cost products. The Tip ‘n Tell middleware supports the implementation of *smart products* and accompanied services. We have presented simple services that help consumers to access product-related multimedia contents and information about similar and additive products. These services leverage semantic annotations that are associated with multimedia contents and tangible products. It is clear that these services are only a very first step towards flexible and robust smart product services. In our future work we will investigate how product descriptions complying with different ontologies can be compared. Furthermore it is important to test our implementation in large scale product environments, such as real retail stores. On service level, we currently develop paid content services and high-level services, such as knowledge-based pricing.

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