Towards a Transition to Tangible Commerce

Design and Evaluation of Conversational Product Interfaces

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Abstract—**Ubiquitous computing technologies disclose new means for consumer product designs that allow products to adapt their behaviour and in particular communication to consumer needs and to interact with other products. In this sense, products become smart. Dialogues between products and consumers require new communicative product interfaces. Because unprecedented, we investigate an implementation of a dialogue-based product interface that is virtually bound to a product via a mobile recommendation agent (MRA) on a PDA and thus reuses knowledge learned by mobile applications. The dialog system of the MRA is tested with the system usability scale (SUS) for a global assessment of its usability to obtain product information (N=47). This preliminary study resulted in promising SUS scores as well as valuable qualitative feedback for future work.**

Keywords:* *Ubiquiotous Computing, e-Commerce, Recommendation Agents

I. Introduction

Consumer products range from simple to complex solutions for everyday consumer problems. Even though that the value of product information on purchase behavior has been found by Marketing research [1], recent trends show that consumer products are promoted more by emotions than information. But, for instance, consumers with allergies depend on precise and comprehendible product information at the point of purchase and in various situations of consumption. Research within the realm of E-Commerce indicates the impact of online recommendation agents on user behavior [2]. Little research has been conducted on the impact of recommendation agents in Mobile Commerce (M-Commerce) [3] and Ubiquitous Commerce (U-Commerce) environments [4]. Tangible Commerce (T-Commerce) is an extension of U-Commerce. It also considers that the user is located in a situation and interacts with other users, physical entities and services. Being in space and time is not just a continuation of time and space experience of online commerce environments, i.e., a user not only generates a mental model of an artificial environment but a mental model of a "real" environment including himself. Questions arise such as "What is behind me?" and "Will this item be heavy to raise?" or "Is this object made of precious material?". Hence, T-Commerce extends the approaches of M- and U-Commerce in the sense that information spaces become part of the physical environment and products in particular instead of referencing into virtual environments while moving and acting in physical environments. T-Commerce foresees tight integrations of virtual and physical environments that adapt to users and generate integrated user experience of products and services.

Low-cost, miniaturized and networked communication technologies as promoted by Ubiquitous Computing research, provide means for products that are able to communicate with users in any situation at any time by adaptation to consumer preferences and activities and other products [5]. Digital representations of global environments are gained by remote sensing systems, such as satellite-based systems or video-based control systems, and used as fundament of innovative services, such as Google Earth. Digital representations of local environments are gained by low-level remote sensing systems, such as RFID technologies, barcode scanning systems and also video-based systems. Hence, we are heading towards a future in which any physical entity has several digital representations so that physical worlds and digital representations become tightly interconnected. Manipulations in either of these worlds will have effect on the other. The key question is: what does this mean for future kinds of products? Products are increasingly required to intelligently adapt to customer needs and changes in usage situations. The future of such smart products will involve having considerable intelligence embedded in the products, which will rely on sensors, processors, and communications module to create smart interactions with customers, other products, and the whole environment. The main idea is to more than satisfy the customers by offering them what they need, what they want, and something they may be interested in once they figure out that such things actually exist.

In order to understand on which levels smart products might adapt to users and situations, we will discuss the context of E-, M-, U- and T-Commerce followed by a discussion of basic concepts of products before we introduce a framework for smart products and present an instance of this framework that was evaluated by an empirical study.

II. From E-Commerce to T-Commerce

Online E- and M-Commerce applications are specialisations of economic markets and span a continuum of institutionalised environments, in which customer-oriented transactions on products and services are performed [6]. In E-

Commerce applications, physical products are represented by product descriptions that define the range of possible pre-purchase interactions with products. By contrast, in-store shopping situations support users with direct perceptions of products by touch, smell, and other sensual cues [7]. Recently, several studies evaluated the impact of digital replications with different sensual experiences by virtual reality simulations, which facilitate further transfer of physical shopping experiences into digital shopping environments [8]. The opposite direction investigates how E-Commerce services can be embedded into physical shopping environments by mobile and ubiquitous computing technologies [3, 9]. With this, rich product information and transaction services become available at the spatial point of sale and can be dynamically adapted to customer's needs. The grounding of product information and services is established by traditional optical such as bar code, or radio communication such as RFID.

A. Mobile Commerce

M-Commerce is perceived as a specialisation of online-based E-Commerce, i.e., E-Commerce applications via mobile devices, such as phones or personal digital assistants [10]. Mobility also adds a spatio-temporal dimension so that E-Commerce applications can be used anytime and anywhere . The spatial context is largely restricted to value-added services based on geo-referencing of the user's location while the interaction between users and mobile E-Commerce applications resemble online E-Commerce applications with additional resource limitations. Mobile technologies can be distinguished from online technologies by value-added attributes: ubiquity, convenience, instant connectivity, personalisation, and localisation. From a value perspective, it is argued that mobile E-Commerce applications deliver values to satisfy user needs: (1) time-critical needs and arrangements; (2) spontaneous needs and decisions; (3) entertainment needs; (4) efficiency needs and goals; and (5) mobility-related needs [11].

B. Ubiquitous Commerce

Watson et al. perceive U-Commerce as a logical extension of E- and M-Commerce [12]. U-commerce is "the use of ubiquitous networks to support personalized and uninterrupted communications and transactions between a firm and its various stakeholders to provide a level of value over, above, and beyond traditional commerce". This metaphoric definition highlights the issue of personalisation/identification and seamless communication everywhere, embedded in everyday life in a non-intrusive and transparent manner. Whether U-Commerce can be conceptually distinguished from M-Commerce is too early to say.

C. Tangible Commerce

Under the umbrella of Ubiquitous Computing and Pervasive Computing context-aware applications are currently introduced. In extension to M-Commerce applications based on standard mobile devices, context-awareness computing has the potential to penetrate all life situations and to provide users with commerce-relevant information and services [13]. By the initial approach of tangible user interfaces (TUI), users interact with digital representations and applications by means of physical representations [14]. Hence, physical entities become avatars for digital information and computational operations [15].

III. The Concept of a Product

In general, products are problem-solutions that are transferred from provider sides to customer sides [16]. Therefore, products intrinsically carry the potential of balancing asymmetries of capabilities between actors. Products are complex structures that communicate between producers, users, and other stakeholders. Product designers engrave their knowledge into a product with the goal to match a company's strategy and capabilities with functional, experiential, and social user needs [17]. Products carry utilitarian and hedonic values [17] that shall be perceived by users not only through the product itself but also through appropriate product staging and associated product information [18]. In purchase situations, the transmission of product values differs characteristically between in-store and online sale situations [19]. For the evaluation of products, Nelson distinguishes search and experience attributes of products [20]. Search attributes can be accessed before purchases while experience attributes are evaluated after purchases. Search attributes stem either from direct experience through, for instance, touch and smell, or are mediated by advertising, catalogues and word-of-mouth. Hence, E-Commerce applications mainly support search attributes but are affected by experience attributes for subsequent purchases. Online E-Commerce but also M-Commerce applications provide interactive product information that can be controlled by users [21]. The interactivity spectrum is spanned from low information interactivity with no freedom in determining the information's sequence characteristics, and high information interactivity with complete freedom [21].

In summary, product information is a mediator for characteristic search attributes while experience attributes are evaluated by direct interaction with products after a purchase. E-Commerce applications are platforms for the communication of product information and facilitate customer's search and subsequent transactions.

IV. Tangible Commerce and Smart Products

D. Tangible Commerce Environments

There are several technological challenges that must be addressed before smart product environments can be implemented. These include how communications are supported among smart products, or distributed communications, and among products and servers or centralized communications. The communications between products and customers should be highly focused and limited to keep the interactions more pleasant. There are major privacy challenges as customers may want to limit who can access information on what products they are interacting with, are buying or have bought in the past. The customers may also be informed on what information about them is being stored and can be released to whom in what circumstances. This could be an obstacle towards adoption of smart products if customers are not comfortable with the level of privacy offered and any potential privacy violations.

E. Enabling Technologies

The current and emerging advances in Ubiquitous Computing and Mobile Technologies help how smart products can communicate with other products and customers. More specifically, sensors and RFID would allow detection of ambient conditions and products. The use of implanted, portable, wearable and environmentally embedded technologies [22] can help realizing the vision of smart products and environments. The access to multiple wireless and mobile networks will extend the reliable range of communications to other products, environments, and potential customers. This will also allow the selection of the best possible network for the type of communications needed [22] such as a wireless LAN to communicate with someone on the same floor, while use of personal area networks such as Bluetooth to someone on the same shelf or close location. Advances in tangible technologies that bridge the physical world with the virtual world may vastly improve the human sensory interaction with smart products and environments. Advances in activity-based computing [23], which deals with how to detect the current user activity based on various environmental and sensory inputs, could further enhance the interaction and communications among smart products, environment and actors in different roles.

Context representations are based on various wireless sensing and communication technologies, such as global sensing technologies (e.g., satellite-based technologies), local optical sensing technologies (e.g., barcodes or video-based sensing), short-range sensing technologies (e.g., RFID), or wireless communication technologies (e.g., WLAN, Bluetooth, Zigbee, NFC, RuBee). Rich context representations, representations about product capabilities and domain knowledge are used by smart products to infer how to learn from and adapt to users and situations. Various technologies are currently evaluated for the implementation of inference mechanisms, such as formal logics (semantic technologies) or probabilistic reasoning, e.g. machine learning technologies.

F. Smart Products

Smart products can be defined as products with digital representations that enable adaptation to physical situations and consumers. An ambient product environment has the intelligence to download, process, and store information on individual customers, their prior interactions with products, and the ability to create pleasant experiences for the customers.

Smart products require new ways for interaction with users [9] that can be used to enable innovative economic concepts [24]. Hence, the vision of smart products raises research questions on the technical side, such as, which architectures are applicable, which kind of semantic representations and processing services are required, which services allow adaptation to consumer needs and which kind of telecommunication infrastructure will enable smart product communication in a secure and robust manner. The rational is to leverage positive effects known from desktop-centered online scenarios, such as purchase decisions [2] or trust building [25] within the context of physical environments. The concept of a smart product extends traditional views on products [26] in the sense that they can adapt tangible products to usage contexts which leads to three core requirements [9]: (R1) adaptation to situational contexts, (R2) adaptation to actors that interact with products or product bundles, and (R3) adaptation to underlying business constraints.

The first requirement (R1) places smart products into a dynamic usage context that is given by a situation consisting of a set of actors, products, services, entities, workflows, protocols, and qualities, such as time, space, or emotions. With the second requirement (R2), smart products are either perceived as an object that can be used in a situation as a tool (product-as-tool) or as a subject (product-as-actor) itself that uses communication skills and is a role-taking entity. The 'product-as-actor' perspective assigns products an anthropomorphic view. Finally, a smart product is required to communicate according to business constraints, such as business rules, business models, transaction models, and legal constraints (R3). Examples for business rules are dynamic pricing and bundling strategies [27].

In compliance with abovementioned core requirements, smart products can be characterised by a framework with six general dimensions [9]: Situatedness: recognition of situational and community contexts (R1), Personalisation: tailoring of products according to buyer's and consumer's needs and affects (R2), Adaptiveness: change product behaviour according to buyer's and consumer's responses and tasks (R2), Pro-activity: anticipation of user's plans and intentions (R2), Business-awareness: consideration of business and legal constraints (R3), and Network capability: ability to communicate and bundle with other products (R3).

The determination of relevant product features for similarity testing is domain dependent. Assertive data is represented by a semantically annotated, ontology-grounded product model, called Smart Product Description Objects (SPDO) [28]. Rule knowledge is represented by standardised web-based rule languages, in particular Semantic Web Rule Language (SWRL) [29]. Smart products are intrinsically able to communicate with users by communication interfaces. The design of such interfaces is an open issue and requires a deeper understanding on which kind of communication is adopted in different situations. For instance, it can be argued that in shopping situations it would be problematic for privacy reasons if a product would speak to a customer while other customers stand around. Instead this communication design would be helpful, for instance, if a washing machine has a defect and the user wants to know what to do.

In the following, we will introduce with Mobile Recommendation Agents (MRA) a conversational interface for smart products that support communication in ubiquitous situations. An instance of this concept will be tested in a shopping situation.

V. Mobile Recommendation Agents

Product recommendation agents within online shopping situations have recently gained major interest in the

Information Systems research community [30]. Integrated sets of recommendation services are defined as "software agents that elicit the interest or preferences of individual users for products either explicitly or implicitly, and make recommendations accordingly" [30, p. 137]. Several studies showed that RAs provide value-added services that help to reduce customer's information overload in shopping situations and reduce search complexity [2], improve decision quality, and increase trust in decisions. Mobile recommendation agents (MRA) are subsumed under the class of RA with a specialisation on in-store situations [3].

In in-store shopping situations, product recommendations are given by sales personnel. For traditional interpersonal sales communication between consumers and sales personnel, product information and style of communication are distinguished [31]. Technical recommendation agents (RA) are aggregators of product information services which can be subsumed by the class of decision support systems. In this sense, RA conceive simple interpersonal sales communication between consumers and sales personnel. From an IS perspective, RA are designed to support goals of consumers, producers, retailers, advertisers and other stakeholder in shopping environments. The focal group of current IS research on RA are consumers that individually use supporting information services provided by RA [30].

In contrast to online RA, MRA are in a very early stage of the innovation life cycle which explains that little IS research has been conducted on MRA [3, 9]. MRA are defined as decision support systems for in-store purchase situations that present product information on the product-in-focus according to consumer preferences, current activities and plans [9].

We perceive MRA as a special kind of a user interface that processes product information and situation-dependent information for real-time product communication at the local point of interaction. This means that MRA are not only localised in time but also in physical and social spaces. Therefore the concept of a MRA has resemblances with more generic approaches such as adaptive user interfaces, tangible user interfaces [14], augmented realities and ambient computing.

Up till now, explicit product information has been static, i.e., was not able to respond to customer needs in shopping situations. First technological approaches show how interactive and adaptive communication functions can be embedded into products [32]. The basis of the communication capabilities of smart products are on the one hand dialogue systems and on the other hand machine-readable representations of the product itself, context models and associated business models [33].

G. Model

The architecture of the MRA consists of a *mobile device*, a *dialogue web service* and a *linguistic knowledge base* [34]. The *GUI control* maintains the user interface and decodes the user interactions into requests, which are sent by the *client system control* to the *dialogue web service*. The *dialogue manager* processes user input, queries correct knowledge bases and returns results to the *mobile device*. The modules *schema processing, lexicon processing* and *SPDO Linker* are involved in the question formulation. At first, the *dialogue manager* queries the set of schema with possible *QuestionTags*. According to the selection of the user one or more schema are activated with pre-configured segments. A scheme is instantiated by incremental processing of each module. The *schema processing* and the *lexicon processing* module have access to the *linguistic knowledge base*, which consists of the *schema* repository and the *lexicon.* The *SPDO linker* constitutes a linkage to the *SPDO broker* of the Tip 'n Tell middleware to query the product information in SPDO format. SPDO information is passed by the *SPDO linker* to the *lexicon processing* module which uses it for scheme instantiation. Results are returned to the *mobile service*.

The MRA has been implemented as part of the existing Tip 'n Tell middleware for smart products [33]. In our current implementation, *Tip 'n Tell* users are in the role of a buyer. They are equipped with an RFID reader (Socket 6E) enabled PDA. Smart products are annotated with RFID tags (ISO15693, HF range with 13,56 MHz), which carry URL references to the location where a product's SPDO is stored. The PDA is connected to the Internet via wireless technologies. The whole Tip 'n Tell architecture is implemented by a web service architecture on the basis of the Jena 2.0 system (jena.sourceforge.net) that allows the integration of reasoning mechanisms, such as Fact++ which is used for compatibility proofs. On mobile client side we use the .Net Compact Framework on PDAs (HP iPAQ Pocket PC).

VI. Usability of the MRA's Dialog System

The dialog system of the MRA was developed for buyers to obtain product information in retail stores, which is accomplished in two consecutive tasks. First, the user starts the dialog function by a pointing gesture at a product by which the product's ID is read via the shopping assist's RFID reader (cf. Figure 1). Second, the user asks for product information by using the question-and-answer-based dialog function (cf. Figure 2). In order to test the usability of the whole dialog system, both tasks had to be considered. For this purpose, we conducted a lab experiment to evaluate the usability of (1) the pointing gesture and (2) the dialog function with the system usability scale (SUS) that is described by [35].

H. Procedure

In the first part of the experiment, the subjects were told to be customers of an electronic retail store that offered mobile navigation units and accessories (cf. Figure 1). Seven mobile navigation units were equipped with an RFID-tag that was fixed below a button labelled *touch me*. Subjects were instructed to buy one of these mobile navigation units and one accessory. Product information could be only obtained by using the MRA's dialog system, thus no printed product labels were shown at all. The subjects had to consider the following constraints: the mobile navigation unit had to be low-priced, had to support the USB-standard and had to include a 1GB SD-Card. In addition, the accessory had to be compatible with the mobile navigation unit they chose. These constraints were formulated such that subjects had to ask several questions at several navigation units, thus getting trained with both tasks the pointing gesture and the dialog function. Name, producer, price and a small image of the product were shown immediately at the top of the screen after the pointing gesture was finished.

In addition, the following four questions were available by a drop down list (cf. Figure 2) a) *Are there product details available?* (e.g., 1GB SD-Card, Dimensions, etc.), b) *Which standards are supported?* (e.g., USB, SD-Card), c) *Which accessories are available?* (e.g., USB-Adapter or bag) and d) *Are there alternative products?* (e.g., other mobile navigation units). Subjects had 10 minutes to finish this part of the experiment.

Then, in the second part of the experiment, subjects were given a questionnaire with the system usability scale (SUS) items [35]. The questionnaire was also used to obtain demographic data and free-text feedback of the dialog system and the experiment.

I. Results

Thirty-eight male and nine female students participated in a lab experiment (N=47). The main focus of their studies was media design (N=18), computer science (N=12) and economics (N=6). Their age ranged *from* 20 to 24 (N=31) and from 25 to 29 (N=16). On a seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7), the instructions of the experiment and the questionnaire were perceived as being reasonable (Mean=6.64; SD=.53) and acceptable on its length (Mean=6.49; SD=.98).

TABLE I. NUMBER OF ITEMS, CRONBACH'S ALPHA COEFFICIENT, AVERAGED SUS SCORE AND STANDARD DEVIATION (SD), T- AND P-VALUE OF ONE SAMPLE T-TESTS (TEST VALUE = 50) FOR BOTH TASKS; N=47

Task	Items	Alpha	SUS score	SD	t-value	p-value
Starting the dialog by a pointing gesture	10	.69	78.8	12.6	16.3	< .001
Usage of the dialog to obtain product info	10	.83	85.8	12.1	19.6	< .001

Reliability of the SUS items was tested with Cronbach's Alpha, which resulted in viable .69 and .83 for the pointing gesture and the dialog function, respectively. The SUS score of the pointing gesture was 78.8 on average and below the dialog function's score that yielded remarkable 85.8 (the score ranges from 0 to 100, see [35]). This result can be explained by the free-text feedback of the subjects that predominantly addressed the slow speed of starting the dialog function with the pointing gesture. This issue is based upon technical restrictions regarding the RFID reader's capabilities. In addition, some subject's requested the ability of the dialog system not only to ask for product information of one product but also to compare different products by their properties. This feature will be considered in the next development loop. Nevertheless, both SUS scores were highly significant above the neutral test value of 50 by applying t-tests for one sample. As a result, the overall usability of the MRA's dialog system is promising with regard to its early development stage. A summary of the descriptive statistics as well as the test results is shown Table 1.

VII. Conclusion and Open Issues

Smart products constitute a new class of products that are able to adapt to users and situations. On implementation level, smart products leverage various kinds of Ubiquitous Computing technologies for sensing changes in situations, identification of other entities and use various Artificial Intelligence technologies for reasoning on context and internal representations. Smart products are part of physical situations and generally address all five senses of a customer. We have argued that the interaction and communication between consumers and smart products generate a new type of a commercial situation in which the being of both, consumer and smart product, in a physical situation becomes an integral part of the commercial task environment. In order to better understand which kind of communication designs are adopted by consumers, we have focused at the communication between smart products via MRA in purchase situations. An evaluation of the usability of a PDA-based MRA indicates that technically savvy users positively react to interactive communication with products in purchase situations. But it also became evident that MRA in purchase situations have to satisfy severe non-functional requirements, such as short response times, and functional requirements, such as comparison services.

This initial study deliberately focused at one particular instance of a MRA for smart products. In a current study we compare different MRA types with various communication designs across different situations of a product life cycle. Another issue of future work is the determination and classification of relevant services that are required by consumers of smart products.

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