Supporting Service Interaction in the Real World

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Abstract. Driven by improved mobile information access and capture, physical mobile interaction is increasingly gaining importance. It uses and exploits the familiar interaction with real world objects in order to provide intuitive access to associated digital information and services. This development is accommodated by the dissemination of the "Internet of Things" in which everyday objects are uniquely identified through wireless markers and have individual network references. Current implementations of physical mobile interaction with services are mostly proprietary and rather simple. Yet we think that its combination with Semantic Web services could greatly improve mobile interaction with digital information and services through associated real world objects. We introduce a conceptual architecture for exploiting semantic descriptions of Web services for the automatic generation of rich user interfaces in order to facilitate physical mobile interaction with objects from the Internet of Things. We also present the results of an early user study and paper-prototyping in order to evaluate our approach to physical mobile interaction.

1 Introduction

Mobile phones have established themselves as devices for accessing and using digital information and services through the interaction with physical objects in the real world. Despite some technical constraints they are rich clients for mobile information access and capture. They are the most widely adapted personal computing platform, always connected to the Web, offer a wide area of technologies and modalities and are used in a rich, dynamic and personalized context.

The richer the means for information access become, the more information can be captured from the physical world and the more interactions with its objects become possible. These objects can be associated with digital information and services that go beyond their inherent amount of data. For example users can take pictures of visual markers [1] in magazines or on posters and use this information for the automatic invocation of associated services [2]. In combination with technologies like RFID or Near Field Communication (NFC) [3] physical mobile interaction [4] is increasingly gaining importance. It reduces mobile payment, identification or access control to simply swiping a mobile phone over a reader. NTT DoCoMo's i-mode FeliCa service for example combines mobile phones with built-in NFC-chips and a service framework based on i-mode [5].

This development is greatly advanced by an increasing industrial effort to tag everyday objects with contactless RFID markers which facilitates their automatic identification, tracking, monitoring and recognition in manufacturing, transportation and logistics. That way, physical objects get individual digital identities, which also makes it easier to reference and present them on a network. This ultimately leads to an “Internet of Things” [6] in which objects as well as their associated information and services can be easily identified and accessed.

In our approach we want to improve physical mobile interaction with objects from the Internet of Things and transfer the familiarity of interacting with them to the interaction with associated information and services in order to make it easier and more intuitive. So far there are mostly simple solutions with single - often visual - markers that act as entry-points for mobile service interaction (see [1, 2]). We want to support more complex physical mobile interactions and shift their focus from mobile phones to physical objects. We want to push service functionalities and options off mobile phones, map them to multiple markers on physical objects and thus turn these into rich ubiquitous interfaces for new and more complex interaction techniques. Instead of struggling through glutted menus, users should be able to choose options and invoke services simply by touching appropriate wireless markers on physical objects.

We also think that interaction with objects from the Internet of Things can greatly benefit from the combination of physical mobile interaction and Semantic Web services. Therefore another focus of our research is to provide a framework that enhances the flexibility and expressiveness of Web services by applying Semantic Web technologies and thus facilitates the automatic generation of user interfaces for advanced physical mobile interaction from Semantic Web service descriptions.

The following chapters will evaluate research related to our approach (chapter 2), provide further details about our architecture (chapter 3) and present results of an early prototyping and user study (chapter 4). Chapter 5 will conclude this paper.

2 Background and Related Work

Fig. 1 shows an early draft of our architecture and outlines some of the key-issues we want to address within our research. Among them are the descriptions of Web services using Semantic Web technologies, the derivation of abstract user interfaces from them and the automatic generation of concrete mobile user interfaces that support the mobile interaction with physical objects? Context information is seen as an important influence on both interface generation and physical interaction.

We model the service infrastructure of our approach exploiting the flexibility of Web services as they provide services through a standardized interface and thus enable interoperability between heterogeneous applications and platforms. Web services are described by the Web Service Description Language (WSDL) [7] which specifies XML grammars for defining communication endpoints for message exchange between heterogeneous systems. Web services grounded on WSDL only provide descriptions and invocation details of single service endpoints. Therefore WSDL descriptions are restricted to simple processes unless assisted by additional technologies for workflow description like OASIS's Business Process Execution Language for Web Services (BPEL4WS) [8] or W3C's Web Services Choreography Description Language (WS-CDL) [9]. Moreover WSDL is only capable of describing input and output messages syntactically. As a consequence Web services have to be invoked and connected manually as no mutual semantic relation can be described through WSDL.

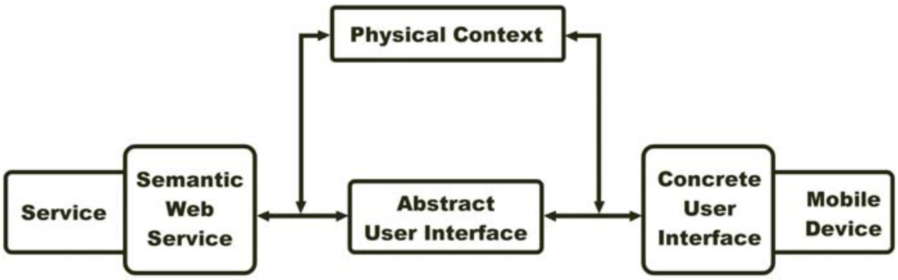

Fig. 1. Early draft of an architecture for physical mobile interaction with real world objects.

To address the shortcomings of WSDL, the Web Ontology Language for Services (OWL-S) [10] for Semantic Web services was developed. OWL-S is an ontology for describing Web services expressed in W3C's Web Ontology Language (OWL) [11]. OWL provides high expressiveness to enrich Web Services semantically. It enables automation of tasks related to Web services, among them capability-based discovery, execution, composition, interoperation, monitoring and recovery. Especially the automatic composition of multiple Web services is a main requirement for providing flexible interaction among them.

We evaluated several interface description languages as a basis for our own automatic interface generation: The User Interface Markup Language (UIML) [12] is a XML-based language for describing interfaces on an abstract and independent level. It supports the rendering of interface descriptions to different target languages using appropriate rendering engines but does not support the creation of several different interfaces from one single description. The Extensible Application Markup Language (XAML) [13] and the XML User Interface Language (XUL) [14] are both XML-based user interface description languages which provide a rich set of concrete graphical elements and widgets but no means for abstract interface description.

Since we include Semantic Web services in our architecture the most interesting approach to describe and generate interfaces is presented in [15]. Therein, OWL-S service descriptions are extended with user interface annotations modelled as OWL ontologies. These extended descriptions are used for the automatic generation and personalisation of form-based interfaces that allow the invocation of according Semantic Web services. The suggested system promises to be most useful for our own approach to generating dynamic interfaces from Web service descriptions.

Since we want to automatically and seamlessly link physical objects and information through the Internet, we also draw inspiration from an infrastructure for weaving the Internet of Things that is currently maintained by EPCglobal Inc. [16]: Similar to our NFC-based approach this infrastructure relies on RFID-tags to attach a unique Electronic Product Code (EPC) to objects. The Object Naming Service (ONS) is used to match the EPC of an object with the URL of its associated information that is stored on a server. The Physical Markup Language (PML) [17] was developed to describe and store the information about an object on the network. PML descriptions of objects – whether provided by Web services or directly by NFC-tags - could be used as input for the invocation of associated Web services.

Our approach to physical mobile interaction is also inspired by similar research about closing the gap between the physical and the digital world: HPLab's Cooltown project [18] tries to link these two domains by providing people, places and things with an individual "web presence", which is similar to uniquely marking objects for easier network reference. [19] presents an early and basic approach to augmenting everyday objects like books, documents or business cards with RFID-Tags. The featured system uses the contactless identification of these objects to reference associated information and invoke simple associated actions on a tablet computer, e.g. opening the electronic file of a document when touching the tagged printout or displaying a person's home page after reading the tag on that person's business card. Since we want to provide more complex physical mobile interaction, our approach will be closer to [20] which also presents a framework for requesting services by touching RFID tags, including a middleware and tags with different functions.

3 Architecture

Our approach tries to combine two domains in order to realize physical mobile interaction: the Internet of Things and Semantic Web services. To bridge the gap between these two domains a mobile device acts as a generic mediator. Fig. 2 shows a high level architecture of our concept including an overview of employed technologies. In order to facilitate our implementation of physical mobile interactions and abstract their complexity we use the Physical Mobile Interaction Framework (PMIF) [4] which supports the interaction with visual markers, RFID/NFC, location information and Bluetooth.

We use the concept of a single Universal Client that is executed on a mobile device and manages the interaction with both physical objects and Web services. It is comprised of an Interaction Client component and a Service Client component which both interact with their corresponding domain.

The Interaction Client handles connections to physical objects and reads information – formatted e.g. with PML [17] - stored on their markers. It also provides one part of the user interface for the interaction with tagged physical objects. Depending on the concrete implementation it generates or at least displays parts of this interface from the interface description which it receives from the Interaction Proxy. The real world object can be seen as a physical extension of that interface. Its tags and markers act like options that hold information e.g. about unique identifiers or parameters for service invocation. That way the interface for interacting with services is spread on both the mobile phone and the physical object, e.g. a poster. This approach is flexible enough to distribute different elements of the interface between mobile phone and physical object, depending on device capabilities, the number of usable tags and the complexity of the interface and its widgets.

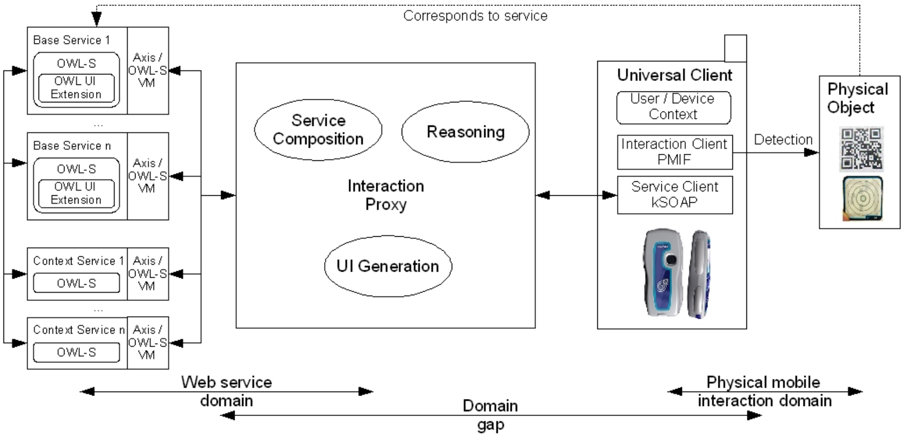

Fig. 2. High Level Architecture

Additionally the Universal Client could maintain context information about the user and the device which may improve automatic user interface generation and reasoning. For example the Universal Client could store a standardized user agent profile which may be used for generating the user interface with regard to the device capabilities.

The Service Client on the other hand provides a generic way of accessing services and controls the interoperation between the client and the service domain.

In the service domain we differentiate between Base Services and Context Services. All services are modelled as Semantic Web services. A physical object is associated with a single Base Service. Base Services are the main service components whereas Context Services provide context information for other services or the Universal client. Services can request each other to fulfil their tasks. By leveraging Semantic Web services we may ensure interoperability between different participating services independent from their underlying implementation or platform. Traditional Web services are enhanced by the support of automatic service selection, service invocation and service composition. Beside the service description, Base Services also provide ontological user interface annotations to enrich the generation of service user interfaces. We want to use OWL-S [10] ontologies to describe services and facilitate the automatic composition of multiple Web services. Moreover OWL-S provides automatic capability-based search which allows flexible and dynamic combination of services without the need of hard-wiring. We tend to use the OWL-S Virtual Machine [21] on top of the Apache Axis framework [22] to invoke and compose services.

As depicted in Fig. 2 we suggest a concept called Interaction Proxy which includes three main tasks for arranging the interoperation between the Universal Client and different Web services: service composition, reasoning and automatic user interface generation. When several different services are interconnected with physical objects, a composition of the services is required. Reasoning supports the interoperability between services by correlating semantic concepts. For example if a service requires a certain input, it may be derived from information that is already available. The automatic generation of a user interface is a main requirement to assist the physical mobile interaction process. This generation must be unified for all involved services to provide a consistent user experience. An abstract representation of the user interface may be derived from the service descriptions to a certain extent, including service inputs and outputs. However it must be mapped to a concrete representation to fulfil usability requirements. We picked up the idea of ontological user interface annotations described in [14] providing the mapping to a concrete user interface which can be rendered on the client. Describing the mapping as ontologies allows the reuse of reasoning facilities provided by the Interaction Proxy.

A central issue of our further investigations regarding the architecture will be the user's role during the interaction process. As the physical mobile interaction with services is a process with possibly several steps of execution a focus lies on the user's role in the interaction loop. This involvement calls for support for special cases such as reversible actions and fault actions.

4 Low Fidelity Prototyping and User Study

For our approach to mobile physical interaction we came up with two use case scenarios for mobile ticketing and conducted an early user study with low fidelity paper-prototypes of a mobile client application (see Fig. 3). The focus of our evaluation was the design and acceptance of our approach to mobile interaction with physical objects.

Fig. 3. Paper-prototype for physical mobile interaction

Fig. 4. Poster with NFC-tags

Fig. 5. NFC-enabled mobile phone

For our application we augmented 2 posters with Near Field Communication (NFC) [4] tags (see Fig. 4). Similar to pushing buttons on an automat, users can touch different options on the posters with an NFC-enabled mobile phone such as the Nokia 3320 with the Nokia NFC shell [23]. The mobile phone selects options through the recognition of the corresponding NFC-tags (see Fig. 5) that are attached to the back of the posters (see Fig. 4). After the user has assembled all necessary options, a client application on the mobile phone would call a Semantic Web service associated with the poster (see Fig. 2).

This scenario is an example for an interface that is distributed between mobile phone and physical object: The mobile phone interface that is rendered from an interface description guides the interaction with markers on the physical object and manages the invocation of the associated Web service. The parameter-values for this invocation are stored on the NFC-tags which represent external options of the mobile phone user interface.

Fig. 6 shows the two posters we designed for our use case scenarios: The first poster allows the purchase of movie tickets and displays a number of appropriate options (title, cinema, etc.). The second poster implements a simplified way to buy tickets for the Munich transportation system. Instead of having to understand the complicated ticketing system, users only have to touch the station they want to start their journey from, their destination, the number of persons and the duration of the ticket. Unfortunately there are too many stations too close together on the map to put a different tag behind each station. Instead we tagged the 4 areas (white, green, yellow and red – see Fig. 6) the transportation map is divided into. Users would have to find their station of choice, remember its association to an area and touch the according tag.

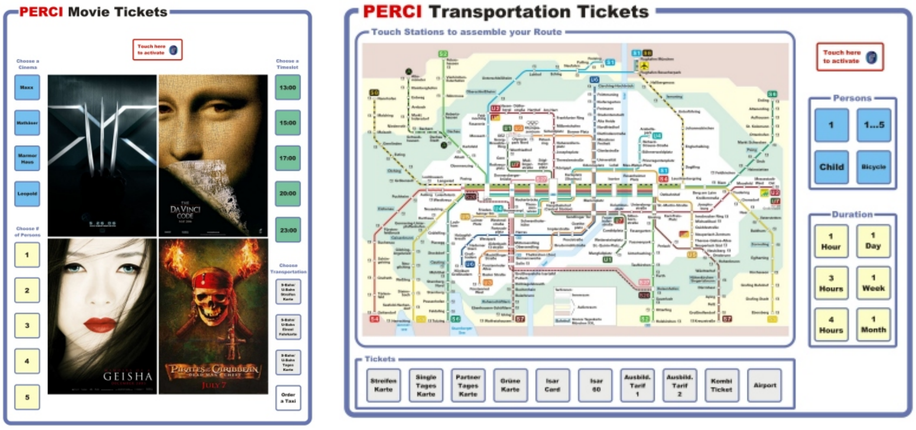

Fig. 6. Prototypes of posters for buying movie- (left) or transportation-tickets (right) [1][2][3][4][5]

We put up life-size versions of our posters in a corridor of the Institute of Media Informatics in Munich and conducted a survey with 10 participants. After an introduction on how NFC-based communication between an augmented poster and a mobile phone would basically work, the participants had to accomplish two tasks – buying

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[1] X-Men 3 Poster. www.actuacine.net/Poster/x-3.jpg. © 2005 Twentieth Century Fox

[2] The DaVinci Code Poster. www.actuacine.net/Poster/davinci.jpg. © Columbia Pictures

[3] Memoires of a Geisha Poster. www.actuacine.net/Poster/geisha.jpg. © Sony Pictures

[4] Pirates of the Caribbean, Dead Man's Chest Poster. www.actuacine.net/Poster/pirates22.jpg. © Disney Pictures

[5] MVV Schnellbahn-Netzplan. http://www.mvg-mobil.de/pdf-dateien/netzplaene/schnellbahnnetzplan.pdf

tickets for a movie and transportation - using the posters and paper-prototype mobile phones (see Fig. 3). These included a mock-up of a client application that provided the users with feedback on their physical interactions with the poster and the associated services. Before and after the two tasks participants of the survey were asked a number of questions about the application and the scenarios.

The results of the survey can be summarized as follows: 75 % of the participants thought that the application was useful and would also use it if it was available – depending on the quality of the implementation and the number of available options. It was often mentioned that such a system could easily replace other automats (e. g. ticketing machines) but also that the human contact and individual feedback was lost compared to e.g. buying tickets at a counter. Although people without a technical background might at first have a certain inhibition level, they are considered to understand and successfully use the application – provided that they are familiar with a mobile phone. The system is largely considered to be intuitive and easy to use even when a certain initial effort is needed to understand it and to get accommodated to it.

When asked about advantages of the system the participants answered that it is faster and cheaper than regular automats and would cause less queuing. The posters can be put up everywhere and are easy to replace. Users are not bound to their desktop computer for ordering tickets online but can do it spontaneously using their mobile phones. The physical interaction is considered to generate fewer faults, to be easy and intuitive to use and to provide an additional value to the omnipresent mobile phone, especially in combination with mobile payment. The new application also causes technical sensation and interest, is considered to be visually interesting and attractive and provides a certain factor of fun. The distributed interaction between posters and mobile phones raises new possibilities for designing this interaction, pushing options from mobile phone menus onto posters and making them less complicated.

The given disadvantages of the system can be related to the system in general and to our concrete application and its lacks of design: For some participants the system was not intuitive enough to use. Posters can only be operated with mobile phones (alternatives should be provided) and have to be put up and actualised. The use of NFC-technology is mostly unknown and would have to be established for common use and interaction. Frequently switching the focus of user attention between the poster and the mobile phone was also seen as a disadvantage.

Many users asked for additional information, e.g. an introduction the system, more feedback during the interaction or a context-aware help for explaining options and the posters' workflow. Users also wanted to know what happened with their tickets after they bought them and how their possession of them was realized. Some users mentioned that a general handling of errors should be provided including the reversibility of actions, e.g. if users want to correct their selections.

As for the transportation poster, most users did not approve the employed method of choosing stations by associating them with different zones. At first most users intuitively touched the appropriate stations to select them. As no feedback was provided from the client, they looked for other means of selection and mostly found the options for the different zones of the transportation map. This definitely raised the need to find a new way for a more intuitive selection of stations.

Another interesting issue was the activator-tag that we placed on one poster and which prompted potential users to start interacting with the poster by touching it. We considered it to be an explicit starting-point for the interaction and most users understood this concept. Nevertheless only half of them appreciated its intention as an explicit entry-point that enhances the structuring of the interaction and the feeling of controlling it. The other half of the users considered it to be useless and wanted to start the physical interaction implicitly by touching the first option on the poster. Sometimes it was even not clear, what was activated by touching this tag, whether it was the poster itself, the mobile client or just the tags.

5 Conclusion

We introduced our approach to mobile interaction with Web services through the physical interaction with associated real world objects. In our suggested architecture we try to exploit the enhanced expressiveness of Semantic Web service descriptions for the automatic generation of mobile interfaces to support this physical mobile interaction with objects from the Internet of Things. We are currently building a prototype for an entertainment use case scenario and conducted a survey using paper-prototyping to investigate the design and acceptance of our approach. As we get some affirmative answers out of this survey, it also shows lacks of our approach. We will have to redesign some of the widgets for physical interaction in order to make their application more obvious to users. Another important issue to think about will be how to guide users through our system and give them more feedback and hints about available options and actions.

Our next steps will cope with implementations on several levels in order to combine Semantic Web services, interface generation and physical mobile interaction in our proposed architecture.

6 Acknowledgement

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