INTELLIGENT MULTI-DEVICE USER INTERFACES

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Keywords: Interfaces, Human-computer interaction, Internet of things, Smart spaces, Proactive computing.

Abstract: Interfaces represent the point of interaction between users and systems, defining their adaptability level in terms of usability and accessibility. These interfaces must advance in the same direction as the information society, where all objects of the world around us are being introduced like services to create the Internet of Things, and so, the Internet of The Future. Therefore, the new interfaces must guarantee that users have access to all information and functionality that the new Internet can provide. Those advances require a new develop interface concept where systems can create interfaces according to applications and users needs, always in a proactive form. In this way, the work presented in this paper tries to define a new semantic and architectural model to create intelligent and multi-device interface which may be adapted proactively according to the context and each users requirements.

1 INTRODUCTION

The continuous evolution of multimedia technology and Internet has enabled the Web to evolve to a new way of communication where users, not necessary expert, can create and use vast amounts of information of different nature (Web 2.0). The next evolutionary leap in the information society and communications will consist of the inclusion of objects in the world around us as direct members of this society, so that users can not only generate or consume information, but may shape the environment in which they live to improve their quality of life (DiY-SE, 2008). These new objects and servers network, Internet of the Future (CERP, 2009), aims to create dynamic information networks made up of millions of interconnected elements so they can process ubiquitous and intelligent information around them, helping to create smart environments.

In this way, due mainly to the wide range of user profiles that can interact with this new Internet, the design and use of interfaces for human-system interaction becomes vital. There are now many tools and technologies that enable users to make and combine devices and serves such as XUI (Organic User Interface) and NUI (Natural User Interface) (Buxton, 2007) (Saffer, 2008), but these techniques require deep technical expertise very specific. There are also tools to automatically create interfaces for specific applications (Krzystof and Daniel, 2004) (Krzystof and Daniel, 2007) (Nichols, 2006) where the background is not so important. In both cases, researchers based their work on the concept of a single user and a single device input/output.

This work intends to delve into this part of the computing science and provide the basis of study for the creation of user interfaces in environments with a huge number of heterogeneous users and devices, both in knowledge and needs and capabilities. Therefore, the goal of this work is to define a model of human-system interaction,advanced and multi-device. This model should adapt the environment information, both input and output, in a proactive way (Tennenhouse, 2008). This adaptation should be done in a context-oriented way, taking into account user needs and their profiles.

2 SPECIFIC GOALS

The main feature of the environment on which this work should work is the model of communication that the Internet of the Future imposes, where the number of devices and users is uncertain and variable. It is impossible to know, in advance, the characteristics of each of these elements. In this scenario is not easy to determine a model of user-system interaction efficient

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DOI: 10.5220/0003399603090312
In *Proceedings of the 1st International Conference on Pervasive and Embedded Computing and Communication Systems* (PECCS-2011), pages 309-312
ISBN: 978-989-8425-48-5
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and correct for every moment.

Therefore, to carry out the work will be necessary to meet a number of sub-targets to facilitate the attainment of the main goal outlined in the introduction. These goals can be classified into the following points:

1. Definition of a general interaction model between environment elements where the Internet of the Future will deploy.
2. Study of different concepts, design features and technologies for the development of multi-device interfaces in order to obtain a semantic model to tackle the problem consistently.
3. Analysis of the different techniques that enable proactive systems to establish the relationship between people and systems, using the more suitable Input/Output device at all times. We have studied the characteristics to be defined within the context of this particular smart spaces type, being very important to define how to create an interface to ensure efficient interaction between users and the environment.

3 NEW INTERACTION CONCEPTS FOR INTERNET OF THE FUTURE

To realize the scope of interaction in the Internet of the Future is necessary explain two concepts: What we understand for multi-device interfaces and how systems can create those interfaces without users supervision.

3.1 Multi-device Interaction

Historically, the development of interfaces has focused on exploiting the concept of one device - one user(A. H. Jørgensen, 2008), basically dealing with environments where the user wants or needs to interact with an application or device. In an environment consisting of an indeterminate number of I/O devices and several users with different knowledge levels and heterogeneous needs, it becomes necessary to move towards a multi-device interaction to obtain the best performance.

In the figure 1 we can observe how the system transforms a tactile interaction to a gestural interaction by using environment elements such as a web cam and public screen. For this, the system uses a device ontology. Each device has a properties list which the system will use to create the new interface, by finding the best I/O device combination.

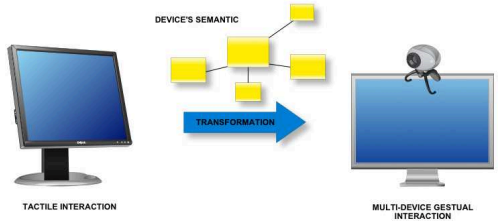

Figure 1: Transformation from Tactile interaction to multi-device gestural interaction.

Therefore, we can define the multi-device interaction as the concept where one or more users use the interaction capabilities of the devices available in the environment (simultaneous or consecutive) to improve the user experience of offered services. The idea behind this concept is to facilitate the creation of similar interfaces using different elements of smart space, enabling user-system communication in situations of loss of interaction points.

3.2 Proactive Modeling Techniques for User Interface and Interaction

Due to that, the goal of this work is to establish a model and a proactive methodology for the interface creation for Input/Output, it is necessary to determine the technique with which the system must generate these interfaces. Originally, techniques for user interface modeling and interaction were developed to assist software engineers in the implementation of visual and attractive applications. By using these techniques they were allowed to raise the level of abstraction focusing the attention on interaction problems rather than the implementation details (Szekely, 2006), obtaining products with fewer errors and higher usability and accessibility degree.

The techniques currently used for developing user interfaces (XUL, Teresa (Paterno et al., 2008), UIMLA (UIML, 2009), UsiXML (Limbourg et al., 2005)) should provide the basis for the development of new proactive techniques where the system decides the best interface at any given time. In this way semantics become very important for the description of the available devices in a smart space, and so, to determinate the best possible interface combination to create the desired interface. Through a proper semantic description and using appropriate artificial intelligent techniques it is possible to define a user interface that facilitates user interaction with the system and otherwise. This has to be done, at least, where the point of interaction is lost due to communication problems or infrastructure.

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4 THE CHALLENGE OF MULTI-DEVICE INTELLIGENT USER INTERFACES

When someone thinks on functional applications, focuses attention on the successful execution of an application (Nielsen, 1999). Interface usability determines the quality degree in terms of ease of use, so this term may be extended to the applications themselves. In this sense, the usability of an application might be defined as the ease of use, i.e. how the application can adapt it self to the user needs and the context in which it is deployed. Therefore, to ensure that any developed application is capable of being executed in any environment, even in the case you do not have the interfaces used by default, is a step toward functional usability.

The following points briefly identify the main research areas that need to be improved to solve the functional usability problems for applications in environments with a large number of users and devices:

Semantic Standardization. In order to define each device and interface uniquely. It is imperative to implement a standard that allows interoperability within the Internet of the Future.

Proactive Development. Once the semantic basis is defined, the system must be able to compose new interfaces by using available I/O devices. For the proper development of a new interface is also necessary to automate the specification and verification of these multi-device interfaces.

Natural Language Processing. Advances in this research field should enable the system to perform the proactive development from a formal description by the users. This should help to increase the usability since it opens the door for less experienced users.

5 CASE OF STUDY

As part of the ITEA-2 Do-it-Yourself Smart Experiences, a first demonstrator of this work has been developed1. This demonstrator visualizes the power of this work through a project of creating multi-device interface for the treatment of public and private information. The main idea of this demonstrator is to force the behavior of a standard output interface to display information in three different devices depending on the location and the data privacy.

First, the user, by using a private device, an Android mobile, sends a restaurant menu request to the server. Then, the server processes the request and retrieves the asked information. This information may be categorized in two types, private and public. Second, the server creates two messages, one to return as response to the mobile device, and another to be put in a public screen. In this way, the system creates a interface which is composed with two output devices, the public screen and the mobile device. A user can visualize private information in their hands, with the Android mobile, while the public information is presented en the screen. The figure 2 show schematically the demonstrators behavior.

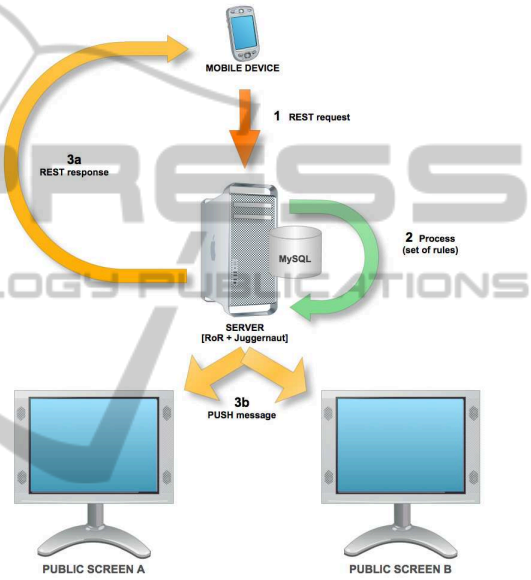

Figure 2: Multi-device Public/Private Information Interface.

The technology used for the demonstrator development is based on the choice of HTTP as a communication channel and HTML5 as programming language for creating applications and REST services. The information remains stored in a database and is composed of a user ID and an XML document with the following structure:

```
<info type="public"> [...] </info>
<info type="private"> [...] </info>
```

Thus, the output system can identify the sections of public and private information for processing. This partition is done by the server, attending a set of rules. By using a PUSH server-based WebSocket it is possible to define two communication channels to send the information published. Each channels is associated to a location that is provided to the system in through a REST request. The system processes information and returns the private part directly to the device which made the REST request. The format of this private in-

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formation is XML, because to make processing easier in the private device.

6 CONCLUSIONS AND FUTURE WORKS

The development of the Internet of the Future and the evolutionary leap of information technologies towards a proactive and ubiquitous model (Tennenhouse, 2008) requires researchers to specify new forms of interaction, where the user should play a less intrusive but supervisor role. In addition, applications need to adapt to new smart environments where they must deploy and operate.

The work presented in this document aims to define the basis for the creation of a architectural and semantic model that allows construction of multi-device interfaces, to improve the interaction between people and information systems within intelligent environments. By using this model, it will be possible to define adaptive applications, in terms of interface, depending of the context where they are deployed and of the user profile.

Nowadays, our research group, Telematic Services Engineering research group (GIST), is working on the implementation of an interfaces translator. This research project should be able to create on the fly interfaces from the interaction model which was defined for a specific application. The new interface will use different devices from the environment to obtain, in a ubiquitous way, the expected functionality.

ACKNOWLEDGEMENTS

This work is framed in the project ITEA-2 Project No 2008005, Do-it-Yourself Smart Experiences, founded by the Spanish MITC -Avanza- TSI-020400-2009-124.

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