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Mobile Interaction in Smart Environments

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Abstract. This 'work in progress' paper presents a framework, a analysis and a design of a set of mobile phone based prototypes. These prototypes have been used to evaluate mobile interaction in smart environments. Other work has shown that mobile phones can act as a universal remote control for the interaction with smart objects but, there has been no research which has analyzed when a given mobile interaction technique should be used. In this research we analyze the appropriateness of three interaction techniques as selection techniques in smart environments, namely *Scanning*, *Pointing* and *Touching*. Our main goal is to understand in which context of use each of these techniques is useful. In support of this aim we have developed a prototype to test *Scanning*, *Pointing* and *Touching* interaction techniques within different scenarios of use. The development process was divided in an analysis, a design and an implementation phase: during all these phases the end user has been involved by questionnaires, interviews, prototyping, and user tests. The results of the finished analysis and design phases are described in this work together with the progress of the implementation phase.

1 Introduction

Currently there is much interest in the field of smart environments. This interest stems from both the potential benefits it can bring to people's everyday lifestyle and the commercial opportunities it offers to companies. The general view is that devices will become increasingly smart and can be controlled via several interfaces [1] [2]. In this context, mobile devices are now starting to be used to control the smart devices. So far these mobile devices are mostly used as universal remote controls whereby the context of use is often not considered. A typical implementation is an application which lists all devices available in a given environment and allowing the user to select one [3]. We call this interaction technique *Scanning*. Other approaches such as *Touching* or *Pointing* at objects, which offer a more direct interaction are not widely researched and we investigated those techniques in more depth in our work.

There are several research projects which focus on novel mobile interaction techniques with real world objects. Välkkynen et al [3] describes a mobile device which supports mobile interaction based on *Scanning, Pointing* and *Touching*. Another project *Xerox tags* from Want [4] describes an environment in which everyday ob-

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jects are enhanced to realize *Touching*. However, so far, the literature reports very little work on the evaluation of mobile interaction techniques in smart environments.

The primary goal of our work is to generate a set of guidelines for the usage of mobile interaction techniques in smart environments. Important aspects in the mode of interaction are contextual issues such as the distance between the user and the device, services provided by the device or the capabilities of the user's mobile device. To address these and other questions, we have developed a prototype for evaluating mobile interactions within smart environments. Therefore we use a development process which is based on user centred design to set the user in the focus so as to retrieve as much user feedback as possible.

2 Analysis

Within our analysis phase we conducted an online survey in November 2005. In this 134 people responded to a questionnaire. 95% of them owned a mobile phone, 29 (22%) were residents of Great Britain and 89 (66%) of Germany. 60% of the participants did not have any technical background.

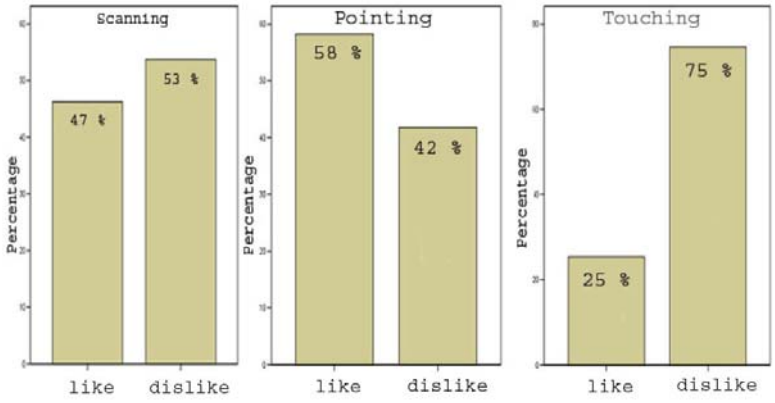

Fig. 1. Preferred mobile interaction techniques in smart environments

The questionnaire explained the mobile interaction techniques in question to the respondents before asking if they would use *Scanning*, *Pointing* or *Touching* when interaction with smart objects in various contexts. Figure 1 summarises the overall findings and shows that in general users would prefer to *Pointing* technique, that they were almost equally split on the use of scanning but disliked *Touching*.

Pointing performs best because many participants saw it as an intuitive interaction technique with little physical effort. Despite it is seen as more complex to use, *Scanning* was preferred where there was a physical distance between the user and the target object. *Touching* proved unpopular because mostly respondents did not see any added value; rather it was seen to entail more unnecessary physical effort. It only reported merit was in situations where touching helped avoid ambiguity.

3 Design phase

The second phase of the user centred design process was to create a low fidelity prototype of the application and to conduct a paper prototyping test. Figure 2 shows some examples of the used paper prototype. The test was conducted by eight people who performed two tasks to verify assumptions in the analysis phase.

Fig.2. Paper prototype

The paper prototyping test showed that the location of the user is the key point when comparing the advantages and disadvantages of the three mobile interaction techniques. The testers were willing to switch interaction techniques but were not willing to expend physical effort. *Pointing* was mainly preferred when the user has a line-of-sight to the smart device. *Scanning* was mainly preferred when there is no line-of sight to the target device, or *Pointing* is difficult to use (small devices or high device cluster). *Touching* was only preferred when the user is already close enough to perform this interaction technique. The user is only willing to expend physical effort when she is highly motivated e.g. when the smart device has some critical role in their life (e.g. a security observation camera). In these cases the testers were prepared to get closer to perform selection via *Touching*.

4 Implementation

We are currently working on the implementation of a high fidelity prototype to evaluate our findings in a more practical context. Figure 3 shows the architecture of the prototype. The mobile phone application is implemented with J2ME communicates via a web server running on top of an UPnP framework to retrieve information and to perform services in the smart environment.

As described earlier, the implementation facilitates user selection via *Scanning*, *Pointing* or *Touching*. To realize these techniques every smart devices is augmented by a solar cell and a Near Field Communication (NFC) [5] tag. *Touching* is realized by a NFC phone (Nokia NFC shell for Nokia 3220 [6]) and a NFC tag. The mobile phone can read the device identifier from the NFC tag when it is in the proximity of the smart device. *Pointing* is realized by a light beam from a laser pointer which is attached to the mobile phone that is sensed by the solar cell on the smart object. After selecting an object, the mobile phone application requests that a data packet is sent to

the web server which includes the device identifier. *Scanning* is realized by Bluetooth access points which provide information about the smart objects in its proximity which are displayed on the user's phone.

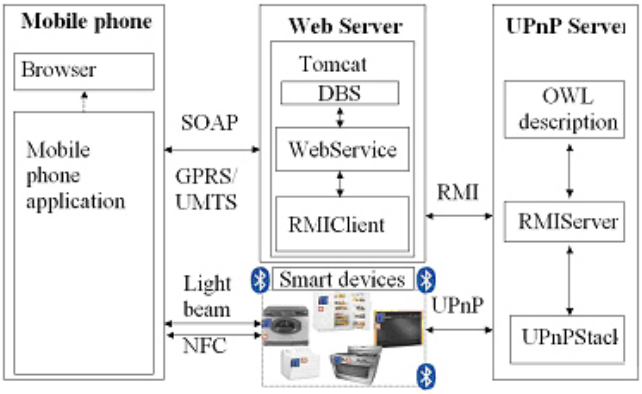

Fig.3. Architecture of the application

Summary and Further Work

We have presented 'work in progress' which concerns the development of a UPnP based framework which both supports scanning, touching and pointing methods of interaction and enables users to evaluate the relative merits of each approach. We have reported on the results of a survey of some 134 people that suggests that a combination of pointing and scanning will provide a popular solution to interaction with devices in pervasive computing environments.

The functional prototype will be evaluated in March 2006 in the iDorm2 [1] test environment of the University of Essex. The iDorm, a purpose built domestic apartment, includes a range of smart devices which can be addressed via UPnP to receive and perform services. The goal is to use the iDorm to verify propositions which arose in our user evaluation survey, such as: Do the users really switch the techniques subject to the distance between the person and the smart object; Do the users always avoid the interaction technique Touching in a smart environment; Are there any other situations in which the user is motivated to spent physical effort to get closer to the device to perform Touching?

Another goal is to find useful services apart from the usage of the mobile device as a universal remote control. Once these in-situ evaluations have been completed we will then finalise a set of guidelines.

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