User Policies in Pervasive Computing Environments

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Abstract. In this paper, we describe the rationale for the initial user research carried out as part of the Natural Habitat project. This project is exploring the extent to which an approach centred on the use of natural language processing can support user control over the pervasive environments that they inhabit. Overviews of four initial user studies are described and some of the wider implications to this area of research are presented.

1 Introduction

The vision of pervasive computing promises to dramatically increase the number of networked devices in our everyday environment connecting to each other as well as to people. Homes, workplaces, vehicles and other environments will contain sensors, programmable controllers and other hardware that is networked together and will provide a wide variety of services within the network. The value of these services will be greatly enhanced if the user is able to tailor their computing environment by composing services to meet their particular requirements. Since many of these computing devices will control and affect personal and domestic aspects of life, they will typically be used by non-technical people [1]. Clearly, these users should not be expected to provide formal specification for how to configure the devices and the services in their environment, in order to carry out their wishes. As pervasive computing gathers momentum and technology blends into the environment, it becomes almost invisible. This invisibility can frustrate users if they cannot easily control or manage their environment. The field of Human-Computer Interaction has a strong tradition of highlighting the need for designs to include appropriate visibility and feedback to the user [2], and these new environments present such a challenge to its designers. This current research project is multidisciplinary, tackling this problem by bringing together and applying research in the fields of Human-Computer Interaction, Natural Language Processing and Networked Services [3].

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We are exploring issues involved in building a system that enables users to employ descriptions of how they want their environment to be tailored (i.e. their policies) with reference to the services that are available to them. A policy in this context [4] is a user defined rule that specifies how some aspect of their environment should behave in response to events and circumstances. The ultimate goal of the system is to allow users to describe, browse and edit their policies by interaction through a multimodal interface in which policies can be expressed using a combination of text, speech and diagrammatic representation. However, there will be cases where ambiguity or conflicts arise in terms of how policies should be interpreted. In order to resolve this, the system will need to present the user with simple, predictable and an easily understood model of what is being processed.

2 Key related research

With increasingly interactive pervasive computing environments one of the key challenges facing user-experience designers is how to manage combinations of devices. Not only must the back-end provide interoperability among a group of devices, applications and services but the facility for a user to interact with these needs to be as intuitive as possible at the front-end. This is essential in order to secure the wider adoption of these technologies.

Typical domestic environments rarely remain constant. For example heating, lighting and types of entertainment leave these environments open to continual change and therefore the need to support this change is essential in the uptake of devices in domestic spaces. Humble et al [5] present a system whereby an "editor" discovers available components and presents them to the user as jigsaw pieces that can be dynamically recombined using a tablet PC. They stress the importance for users to be able to quickly place devices in the home, understand this placement and rapidly reconfigure device arrangements. Indeed Beckmann et al [6] comment that as the costs of sensors comes down users are increasingly likely to actively participate in the installation process in their own environments and suggest those that do gain a greater sense of control over their application. Perhaps they are likely to gain a heightened awareness of their own configurations compared to those that are not as involved in this installation process?

Hull et al [7] recognise that users need a simple way of specifying applications that does not require specialised technical knowledge. One such way is to take advantage of the users own natural language. This has been demonstrated to some degree in the work of Truong at al [8] whereby the user can create applications in a way that takes advantage of the flexibility of natural language using a magnetic poetry. Presenting users with comic strip representations of scenarios of uses of this technology they were able to understand how users naturally conceptualise these domestic applications. Having then defined the types of models derived from these results they then designed a set of restricted domain-specific vocabulary that would help users express their ideas flexibly.

3 Initial Project Studies

The Natural Habitat project is researching how a system can handle users' natural language requests in order to manage an environment where a multitude of devices and services are available. It was considered imperative that end-users be engaged from the outset in order to gather realistic scenarios and capture user policies in their natural language. A series of short exploratory studies were undertaken to capture real policies and to see how methods of user engagement fared. These user policies could then be used to consider how a system would cope with these expressions.

Study 1 - Printing scenario: A general email questionnaire was sent out within a multi-disciplinary University department asking recipients about their use of printers in the work place. The intention was to begin to explore the design issues required to recognise and support different styles of policy. In their responses users specified policies about which printers they use under which circumstances. Twenty respondents were then given a print out of their original replies and asked to type into a dialogue box how they would instruct a computer system "with limited world knowledge" in their own words to manage these printer preferences (policies) that they had. There were several differences in the way users expressed themselves. Some used a kind of simple natural language, others introducing logic and even one attempt in Java. This is perhaps an indication that different people will have different expectations of how robust such a system would be. Issues of ambiguity were also highlighted. The term *nearest* could mean nearest to the user physically at that moment, nearest to their office, or nearest to their next appointment such as a meeting. Additionally, the question of what is meant by a large document? Is it the number of pages it has or the size of the file?

Study 2 - the Magic Wand: The previous study engaged with users in a way where they would describe their policies in a perceived sense rather than in an actual sense. In other words, these were policies that may have been out of context from an actual printing task, offering an indication how a user may wish to set up their printing policies. The next study set out to investigate how users generate policies *on the fly* using spoken language. A small pocket sized digital recording device was given to five individuals for a week and they were instructed to offer policies whenever they occurred in their everyday activities as if waving a magic wand. This was a useful methodology to get closer to more realistic examples of how a user may wish to manage a system controlling devices and services within their own environment.

Study 3 - Personal Communications Management: The first study focused on one task, printing. This study examined how users may manage their communications (e.g. their diary, telephone(s), text messages, voice mail, email, and other Internet services) across devices and different contexts. Ten participants took part in individual semi-structured interviews to gather an outline of how their personal communications were managed. They were then asked to type into a system dialogue box their instructions to a system to manage these for them. As with the first study, many participants' instructions to the system would not

have adequately carried out their policies as originally described and would have caused system conflicts or uncertainty due to their ambiguity. Feedback from the system would have to be carefully managed. We even had one participant using polite language to describe their policies using expressions such as "I would like" and "please".

Study 4 - Policy conflicts in a domestic setting: The final short study in this series wanted to examine how users react to, and how they may wish to, resolve conflicts where a new policy may alter an existing policy. To investigate this, a single floor-plan of a living environment was individually presented to ten participants together with twelve pre- designed policies of how the domestic environment would react to certain circumstances. These were shuffled before each session and the participant could arrange them in front of them however they wished. The policies were constructed in order to generate a few conflicts and the participants' expectations of system behaviour gathered. Their expectations varied, some thought the system would assume some policies would obviously take priority over others as would one person's over another's. Other participants thought the system would stop at a certain point whilst others assumed the system would seek clarification from the user.

4 Implications and Future Work

While researchers and reporters in the area of pervasive computing can get very excited about the possibilities of future pervasive technologies, it was noted in these studies that to many non-technical users these applications rarely seem vital additions to their already increasing reliance on technology. Indeed many classic descriptions [9] of future technologically enhanced environments failed to really capture the imagination of our participants. We are yet to present a *killer application* that could inspire people and therefore speed up the adoption of these technologies, and this is one of the major challenges to researchers working in this area.

There is also a concern that many people lack a good enough understanding of the nature of networked devices to realise their potential in supporting their everyday lives. Indeed, Light [10] reports how the 17-strong international Digital Home Working Group have recognised the need for a new type of staff in shops to help people choose these new types of components. Education of consumers is to be a priority. Even governments are considering large investments in training in order to generate a better public understanding of networked devices and their potential, in order to spur on the adoption of such technologies. It is perceived that early adoption of these technologies will be of significant benefit for a country's economy and help drive the global market.

Developers of these future services will need to have a strong understanding of how users will want to express their policies in order to design robust systems and this may be key to the adoption and survival of their product. The danger of a system not working effectively immediately, causing user frustration and loss of control will almost certainly adversely affect the credibility of the technology and slow down its adoption. Traditional HCI methodologies will have their place, but

we may have to explore and develop new techniques to help us create more seamless interactions with technology. Traditional methods have focused on testing, however careful attention will now have to be paid on gathering user requirements to gain a better understanding of users and their cultures.

- How can we engage with potential users that do not understand network services and policies as developers do?
- How do people know what they want if they do not understand what the system is capable of, or if the interface is almost invisible?
- How can non-technical users tailor their environment using intuitive interfaces such as natural language, speech and GUIs?
- How will users express their policies to be interpreted by the system?
- What will interfaces of the future look like with less reliance on the screen and pointing devices?
- How do users conceptualise applications and then configure them to suit their needs?
- What methodologies of user engagement are appropriate in the development of these technologies?

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