Creating and Modeling the User Experience in a Residential Gateway Environment

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ABSTRACT

A Residential Gateway (RG) interconnects a home network and an access network. The RG delivers broadband multimedia services in the home, and acts as an autonomous personalized control unit to end-user equipment. The potential complexity of such a system is overwhelming. This paper describes novel work towards building an interaction approach that hides system complexity from the user by using machine learning techniques that anticipate user moods. The system is accessed via a multi-platform user interface that includes use of tangible tokens, a wall projected display with gesture tracking, a pen tablet, and a PDA. An approach based on a home stage and setting atmospheres in the house is described as a way to structure RG functionality. The proposed agent-based system architecture includes a central user-modeling agent that processes updates from all connected products. Using a rule-based expert system in combination with pattern recognition, the agent module can suggest to the user new in-house products settings. Personalization is supported by enabling the user to program and invoke new mood settings via the tangible tokens and by changing object settings in the stage metaphor. The work involves close collaboration between industry research labs and academia.

KEYWORDS

Residential Gateway, user modeling, personalization, tangible interfaces.

INTRODUCTION

In the future, consumers at home will be able to use a Residential Gateway (RG) to connect their intelligent home network to an access network (Figure 1). Such a network offers access to the public infrastructure via cable, telephony network or fiber optics and new broadband services with interactive personalized multimedia. The home network interconnects end-user equipment in the home, thus making it possible to introduce home automation. Also, the RG can be user aware, so system behavior can be adapted to its users.

Although technically an RG offers many attractive new possibilities, from a user point of view the potential complexity of such a system is overwhelming. Current research in the field focuses mainly on network issues and on product specific user interfaces. Most of the hardware and software components needed for the RG are already available off-the-shelf; the seamless integration of these parts into an integrated system is the challenge we face [Satyanarayanan, 2001]. There is a need for a house-level user interface that hides complexity to the user. In this paper we describe one possible approach towards fulfilling such a need.

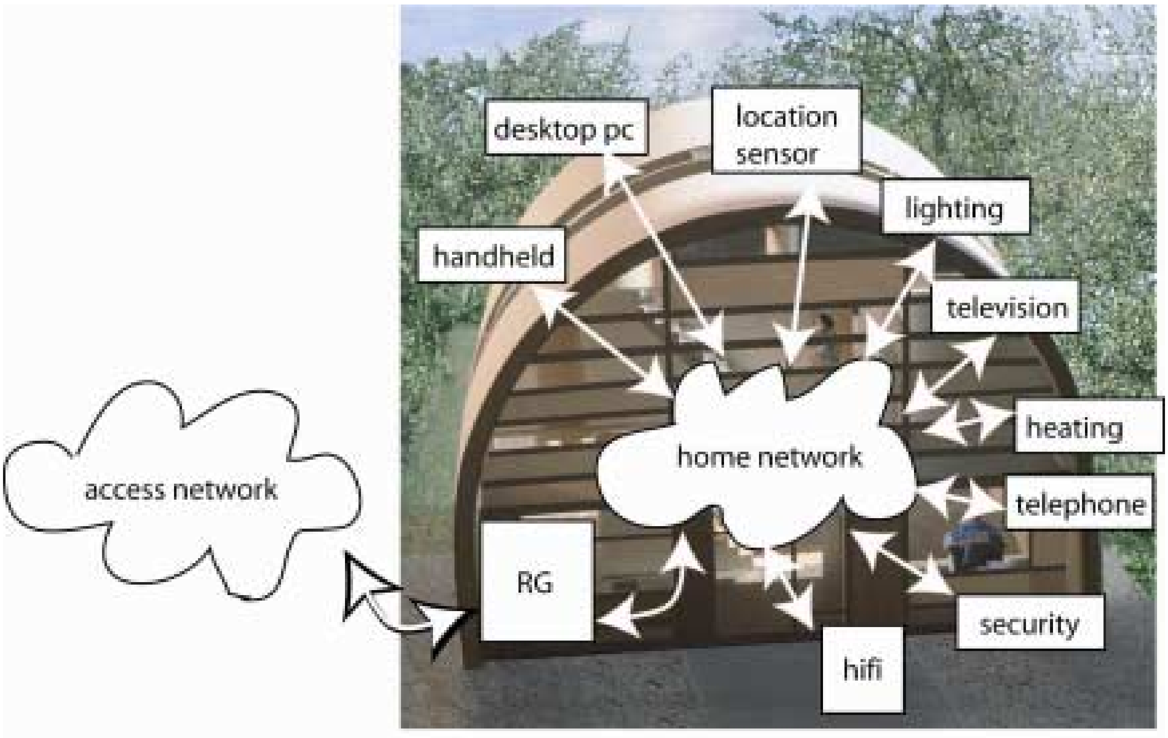

Figure 1: The Residential Gateway connects the home network to the access network.

The main objective of the Residential Gateway Environment user interface work package, as one of several research areas in an RG research program, is the integration of automation, communication, entertainment, and information RG functionality via an intelligent user interface. The project includes members from industry and academia, with staff from Delft University of Technology, KPN Research, Philips Research and Eindhoven University of Technology.

With the RG, we want to make users feel comfortable at home. As a first step we focus on mood-based selection of music, video and light. In the background the RG will perform pattern recognition, in order to update user preferences automatically. The architecture and supported RG functionality will be extended in future.

THE INTELLIGENT HOME STAGE CONCEPT

Towards integrating functionality in the RGE a common interaction concept is proposed based on the notion of a stage with RG functionality represented as objects on the stage. The stage is referred to herein as an Intelligent Home Stage (IHS). The goal of the IHS is to enable the user to combine or link RG functionality via intuitive object based metaphors. For example, the user may wish to link a wall display of email messages with an agenda and motion sensor, such that email messages are displayed at certain times of the day if the user walks by the wall.

In addition to integrating RG functionality, an important goal of the IHS is to provide to the user a sense of a consistent interaction style as the user moves between platforms of interaction with the RG. For example, the user may interact with the IHS, via a mobile interface, fixed display interface or tangible interface. In essence, the way in which a user moves objects into and out of the IHS should be consistent regardless of the modality of interaction. Spoken commands should appear the same as visual commands and the order or sequence of events should remain consistent. Representations afforded by tangible interfaces could also appear in visual displays or described in an auditory-only interface.

In supporting the IHS concept, a number of concepts can be identified. All objects that represent system functionality appear in the **stage.** As mentioned above, the stage need not be visual-only. A given setup of ICEA (Information, Communication, Entertainment, and Automation) linked RG functionality is represented on the stage as a **scene**. The user can navigate between scenes so as to rapidly invoke a new collection of RG settings. RG functionality represented on the stage takes on the form of a **prop**. For example this could be an agenda, a lamp, a Internet bookmark, the alarm bell, door switch, time, or TV. Closely related props such as two different TV programs may have similar visualizations. The user interacting with the IHS can be thought of as **the stage director.** The stage director can create a certain stage by ordering props or groups of propos, depending on the desired activity, or the system may suggest certain props depending upon availability and past user behavior. The user communicates with the IHS via **the stage manager**. The stage manager is a personal agent. The user can consult the stage manager to find out what props are available and how to create or edit a stage. The stage manager can help resolve conflicts. The user communicates via a visual user interface, spoken, and/or textual dialogue. An **assistant stage manager**, as a second agent, helps the user control a given service once it has been placed on the stage with the help of the stage manager.

MOOD-BASED USER INTERFACES

An important concept of the intelligent home stage is easy of use as communicated through aesthetically pleasing and easy to use interaction concepts [Norman, 2002]. One way to combine functionality in an appealing way is by enabling the user to setup RG related functionality according to a desired atmosphere. As a case in point, a user wishing to organize a romantic dinner may like the lights to be dimmed. To do so, the user would have to set each individual light appropriately. Ideally, the user should be able to communicate such a desired atmosphere to the RG system. The system should be able to suggest and learn settings for the romantic atmosphere, including other related mood-coupled functionality such as music, the temperature, window shades, or perhaps a certain video projection on a wall.

An RG is a technological enabler for talking *about* products. This paradigm shift must be visible in the RG user interface. An interesting analogy is the MoodLogic (http://www.moodlogic.com) program in the music domain. MoodLogic can be considered to be a music companion that can generate a play list for you based on your mood.

Users may reject an RG system with home atmosphere control if they have to manually program it extensively. In the current approach a database with default mood settings will be adapted to individual users. It will be essential to have a user modeling system that can detect patterns in user behavior and can automatically update settings. As the system adapts autonomously and gradually according to user preferences indicated explicitly or implicitly, the acceptance of the system is expected to increase. For more experienced users, the user interface should allow manual changing of settings. The current paper deals with the automatic setting of RG functionality.

PHYCONS AND TANGIBLE INTERACTION

Tangible interaction can be an intuitive way to communicate mood with an RG. New tangible and multi-modal input and output devices can help build a dynamic interactive environment in a natural way. For example, physical icons (phycons) have been created to express different components of music [Hummels]. Figure 2 below shows Poco, which consists of a reader and a collection of phycons. The phycons on the right depict rhythm, the left section depicts chords, and the lower middle group of phycons depicts sound samples. The user can combine phycons and place them on the center turntable that in term generates music according to the form of the icons. In the future the Poco user model should support programming new music elements in the phycons or entire songs per phycon. In the RG situation, other mood related functionality might be communicated via phycons, for example lighting options.

Figure 2: Poco: an example of a user interface that can be used for moods.

USER MODELING AND PERSONALIZATION

The analogy with a butler, albeit often made [Aarts, 2002], may be well suited for the RG. The butler works in the background, with a minimal level of user disturbance. The butler learns user preferences by either being taught or by observing user behavior. The RG system must be aware of the environment it is working in, it needs to know about the house in which it operates, about the home network installed, and about the functionality and state of the products attached. Using this information the RG knows when and how to change the state of the environment.

The RG aims to please the users. It has to find out what users are around, what they are doing, and what they would like the system to do. The RG processes collected data into user models that are used to personalize product settings.

Before considering the types of information that could be stored in the user models, an understanding of what the user model module can be used for is first needed. In this manner one can ensure information is added to the model only when it is likely to be used at some point in the future. Due to limited processing, storage and communication resources, the amount of information modeled must be minimalized.

Possible applications of information gained via the user model include:

- Change of product settings based on individual user preferences for mood, activity and event settings.
- Pro-actively adapt the RG to future product usage, based on patterns in historical interaction and product state data.
- Personalize user-system interaction.

Information stored in order to be able to supply the information mentioned above includes:

- Identification and location of the users.
- Mood, activity and event-based product settings for individual users.
- An interaction history.
- User tasks. The explicit modeling of tasks allows for task-context-sensitive dialog adaptation and pro-active user guidance.

In the RG environment, mobile devices are used with limited communication bandwidth. Bandwidth can be saved by dynamically adapting the information flow towards the central user model based on the situation. The central user-modeling module will communicate information needed to connected mobile devices.

PRIVACY AND TRANSPARENCY

To ensure privacy of information in the RG the user should be the owner of all personal information in the system. The user should be able to choose what information is shared with the outside world. The RG information flow should be transparent to the user.

Related to the issue of privacy in the RG is transparency in the user model. Users should be able to view what information is known about the user as well as being able to edit such data. It is expected that the user will trust the system and be more willing to engage it given a transparent user model.

AGENT-BASED ARCHITECTURE

As described above, the RG system can connect many products in the house. The proposed RG system architecture includes a central module for system management, dialog control and user modeling. The proposed architecture is described below.

Figure 3 shows a high-level architecture overview of the agents in the RG system used for mood modeling. The system is being implemented in Java; a first prototype is scheduled for late 2002.

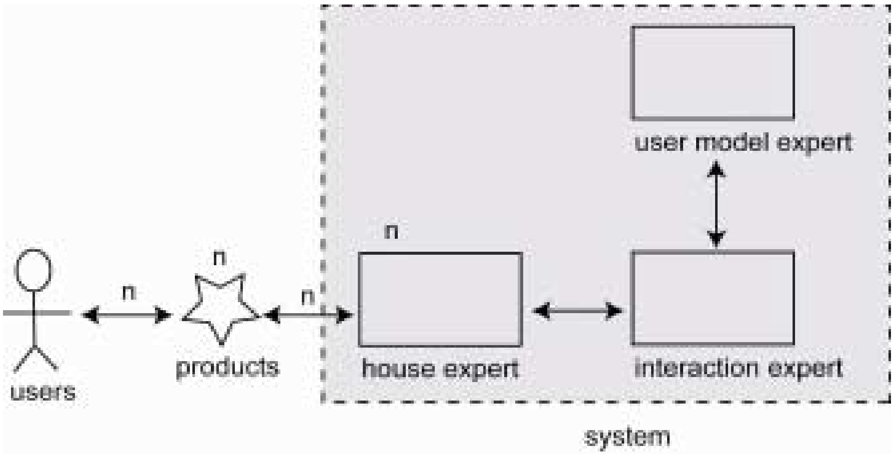

Figure 3: Architecture overview.

The arrow on the left depicts the interaction between users and products in the house. Products are connected to the system via the house expert, which is discussed below. Product state changes are communicated to the interaction expert. The interaction expert updates its models and manages the user system interaction. To enable interaction with the user, output devices are selected and activated via the house expert. Using the knowledge of the user model expert, the interaction expert can personalize the interaction.

INTERACTION EXPERT

The interaction expert manages the high-level user system interaction. Functions of the interaction expert include user interface display management, dialog management and modality selection. Expertise from the user model expert is used to personalize the interaction. The house expert serves as an adapter between the interaction expert and product. Since the RG system has to deal with multiple users and potentially conflicting preferences, the interaction export has to perform conflict detection and resolution.

USER MODEL EXPERT

The user model expert provides a range of user related information that can be used to personalize user system interaction and to adapt product settings. For each individual user the user model expert links moods to RG functionality.

Based on the overview of frequently found services as described by Kobsa [1995], the user model expert provides the following services to the system:

- Formation, representation and the provision of assumptions about user characteristics in models of individual users, as well as justifications for these assumptions
- Representation of relevant common characteristics of users pertaining to specific user subgroups of the system
- Classification of users into these subgroups, and the integration of the typical characteristics of these subgroups into the current individual user model
- Recording of users' behavior, and the generalization of interaction histories of many users into stereotypes
- Consistency maintenance in the user model

The agent collects information from different sources, puts the information in a user model, and tries to discover the desired mood or atmosphere setting. A rule-based expert system is foreseen to predict the preferred new state of the environment based on the current state and on the preferences stored. The expert reasons about preferences, abilities, tasks, plans, goals, history, knowledge, misconceptions, performance and mood. An annoyance attribute will be used to predict whether or not the user can be disturbed with questions [Orwant, 1993]. Pattern recognition techniques will be used to identify trends and make suggestions. The current project seeks to find an appropriate technique for modeling users and products in order to be able to detect the patterns. Currently, plans include the use JESS [Friedman-Hill, 2001] for reasoning; Collagen [Rich, 2000] could be used for tracking the user in performing tasks while offering suggestions.

HOUSE EXPERT

The house expert (Figure 4) represents and controls physical objects in a house. For selected products, the module has a corresponding product agent that processes external state changes that are communicated to the system and processes internal requests to control the physical products. The house expert communicates with house products via existing wireless channels such as infrared or Internet.

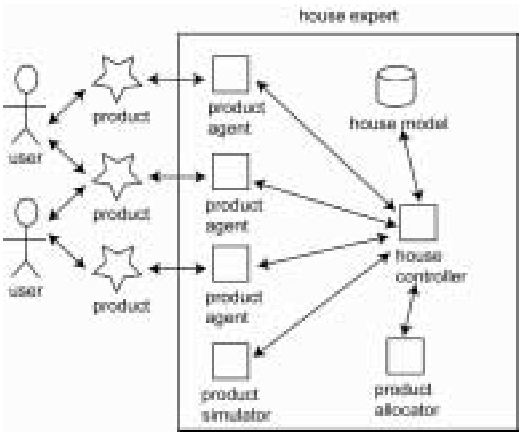

Figure 4: The house expert.

The success of a residential gateway environment will partly depend on the plug-and-play ability of products. Users may want to be able to easily add components and new services, without having to call a specialized technician for assistance.

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