Casalendar: a temporal interface for automated homes

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Abstract

Smart homes with advanced building technologies can react to sensor triggers in a variety of preconfigured ways. These rules are usually only visible within designated configuration interfaces. For this reason inhabitants who are not actively involved in the configuration process can be taken by surprise by the effects of such rules, such as for example the unexpected automated actions of lights or shades. To provide these inhabitants with better means to understand their home, as well as to increase their motivation to actively engage with its configuration, we propose Casalendar, a visualization that integrates the status of smart home technologies into the familiar interface of a calendar. We present our design and initial findings about the application of a temporal metaphor in smart home interfaces.

Author Keywords

Smart Homes; Home Automation; Calendars.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction and Motivation

Homes that are equipped with advanced building technologies and means for automation are becoming

more widespread. There are several challenges to address in order to support the transition from a home that is simply equipped with a myriad of heterogeneous automation technologies into a home that supports and facilitates inhabitants' daily life. It is still an ongoing challenge to integrate the variety of functionalities from a technical point of view. HomeOS [2], Loxone[1], and nomos system[2] are some examples of efforts in research and industry to provide developers as well as end users with easier and more unified access to smart home technologies.

Being able to understand adaptive and automatic behavior is not only important to control such technologies, but also so users can trust and rely on them [3]. From related work we know that the more "intelligent" technologies become, the more difficult it is to understand and predict their effects [10]. Thus, smart homes require interfaces that allow inhabitants to navigate, understand, and interact with a potentially overwhelming amount of information and controls. However, despite technical advances and recent industry attempts to improve usability, the understanding and control of home automation technologies, supporting these is still challenging [1].

In our prior studies we discovered that inhabitants, especially those who do not have technical knowledge, have problems administering, troubleshooting and ultimately deriving benefits from smart home technologies [7][8]. Lack of understanding of the home's behavior was often the primary source of frustration for inhabitants. However, when a

functionality of the home was well understood, inhabitants were better able to generate ideas for beneficial ways to adapt the technologies to their home routines.

Building upon these insights, we designed Casalendar, a smart home interface that allows inhabitants to interact with integrated building technologies, with two goals in mind: 1) facilitating better understanding of automated home functionalities by visualizing aggregated events in the home (past, present and future) in a single interface; 2) facilitating control of automated home technologies by offering more means to easily modify existing events and create new ones.

Related Work

To enable user control and comprehension of building technologies, researchers have developed a variety of tools for end-user programming and the visualization of components and functionalities. Some work takes advantage of familiar metaphors: Humble et al. [5] developed a tablet PC application that allows inhabitants to configure ubiquitous devices for domestic environments by connecting virtual jigsaw puzzle pieces; Truong et al. [12] use a virtual magnetic poetry metaphor to translate the user's description of an intended behavior into instructions for the related devices.

Substantial related work has looked at organization, coordination, and communication in domestic environments. Neustaedter et al. [1] identified time-based scheduling, especially through family calendars, as one of the key ways in which people organize and communicate events in the home. Many home automation functionalities and configurations relate to

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[1] http://www.loxone.com

[2] http://www.nomos-system.com

Figure 1: Screenshot of an example of a KNX visualization (EisBär KNX[4]) using floor plans
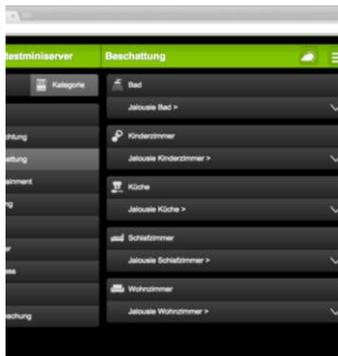

Figure 2: Screenshot of Loxone's user interface using a list with rooms

people's routines [6], but thus far spatial metaphors are far more common than temporal metaphors in commercial home automation interfaces, for example in most KNX[3] visualizations (Figure 1 shows an example of EisBär KNX[4]) or Loxone's user interface (see Figure 2). Building upon previous work, we explore how temporal metaphors can facilitate the integration of building and automation technologies into daily life.

Metaphors in smart home interfaces

In order to increase acceptance and trust of automation technologies we need to foster intelligibility [10]. Smart home technologies are often not entirely automated, but rather are mixed-initiative systems [4] in which the technology provides the means to run automated actions based on explicit user input. Therefore, to enable better smart home interactions and to facilitate informed control when necessary, we need to enable an appropriate level of understanding.

Traditional smart home interfaces make use of ordered lists of function categories or rooms (see Figure 2) or more visual spatial metaphors such as floor plans or room plans (see Figure 1) to visualize system status. The main purpose of these interfaces is to provide easy access to components of the smart home system and the configuration of their settings. As a result they are geared less towards facilitating an understanding of how the system works.

Temporal metaphors could help provide a broader view of a smart home's state and offer new options for interaction with home automation systems. Thus far,

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[3] http://www.knx.org

[4] http://www.busbaer.de/

they have not been extensively investigated. Routines and activities happening in the home have an inherently temporal nature that is difficult to capture with spatial metaphors. We could hypothesize that this is the reason why people prefer to use calendars over maps to keep track of everyday life. People are familiar with using calendars to organize and coordinate their lives providing an additional reason to explore temporal metaphors for smart home interactions. Oftentimes, automation in the home happens in several places at the same time or even uses event triggers that do not have a spatial physical location, such as time of the day or control through remote access. But they all manifest their effects at a certain moment in time.

Following a strict temporal metaphor approach introduces other limitations and might not be a suitable approach for all smart home components. In consequence, we expect our prototypes to evolve to a hybrid interface that uses temporal metaphors to add to the overall experience, not as the sole representation.

Initial prototypes

Goals. We first conducted a study of smart home inhabitants to gain understanding of the general field of current smart homes "in the wild" [7]. From this work we identified the frustrations of "passive users", smart home inhabitants who are *not* the household members responsible for the home configuration, in comprehending and controlling their homes. Based on these insights we conducted a follow-up study with passive users living in smart homes to elicit their everyday experiences with their homes through a mixed-methods approach using diary studies and semi-structured interviews during home tours [9].
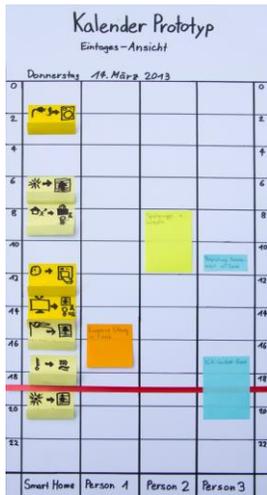
Figure 3: Calendar prototype displaying smart home events along with personal calendars
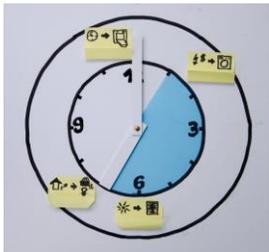

Figure 4: Clock prototype showing past and future smart home events

Figure 5: Study setup of our think aloud study

Because many participants expressed a lack of interest in participating actively in the configuration of the smart home technologies, we decided to focus on improving the understanding of these technologies. However, as we found that participants expressed ideas for modifications of the home technologies with which they felt most comfortable, we kept in mind that our interface should be designed such that it might eventually also support control and configuration.

Design. Our participants perceived a disconnect between their routines and the available technologies and felt that the benefits they could derive from their home technologies were limited. Thus, our primary design goal was to create a single interface that would draw meaningful connections between routines and technologies. With those goals in mind, we designed Casalendar, a calendar-based interface that integrates the schedule of a home's automated technologies and its inhabitants' personal schedules.

To overcome passive users' reluctance to use novel interfaces and lack of confidence in them we used familiar temporal metaphors (i.e., a clock and a calendar) to display information about a smart home's state and provide means to interact with the system. For both metaphors we developed a paper prototype (see Figure 3 and Figure 4).

Evaluation process. Five HCI experts evaluated the prototypes to identify weaknesses in the concepts and the general interface design. After a minor revision, those prototypes were evaluated using a think aloud study (see Figure 5) with six participants (3 male, 3 female) who lived with at least one more person and had little to no technical experience. Their ages ranged

between 22 and 57 (Mdn = 51, μ = 45.2). Participants' characteristics and age range were targeted to represent our intended audience of "new" users of smart home technologies. Besides catching issues with the interface design, our goal in this early study was to learn about whether participants understand the temporal metaphors, whether they see any benefit in them, and how they envision using them.

Key findings. Participants indicated that they understood the concept of the home having a calendar and of events being automatically placed on a temporal interface. One of the participants liked that *"with the proposed prototype there is no need for explicit attention to automated [actions], but it could be checked if something is unclear."* Because our participants expressed a strong interest in the personal calendars and perceived the clock metaphor as limited in terms of time span and clarity, we decided to focus our subsequent efforts on the calendar metaphor.

Interactive Prototype: Casalendar

To investigate the calendar metaphor not only from a conceptual point of view but for its application in real life usage, we developed an interactive prototype.

Goals. Including interactive features from common digital calendars allowed us to explore potential conceptual mismatches between participants' mental models of existing calendar tools and the proposed home's calendar.

Design and implementation. We revised the calendar design, addressing issues identified in the paper prototype evaluation, such as insufficient differentiation
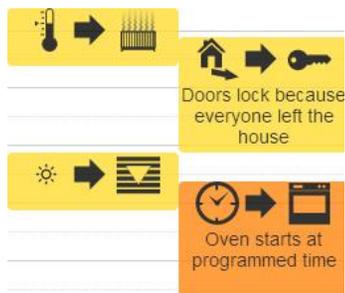
Figure 6: Interface detail showing examples of used pictograms and descriptions of smart home events
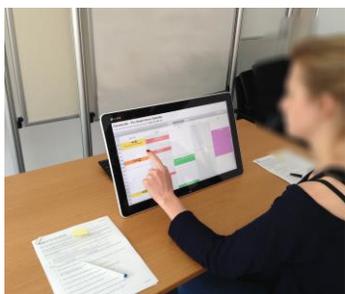

Figure 7: Study setup for the expert evaluation showing the Casalendar prototype on a multitouch screen

between various event trigger categories and icons that were difficult to identify.

The current prototype is a web application (see Figure 8) that takes data from a calendar server. Smart home events are gathered from this server as standard calendar events (CalDav) with additional information about which devices are affected by a particular event. In order to display the calendar view, the framework jquery-week-calendar[5] was used. This framework uses several JavaScript and jQuery libraries to display a HTML5 web page. In its current state, Casalendar can display actual personal calendar events from any calendar service that provides its content as an ics-file alongside simulated smart home events either in a week view (see Figure 8) or in a daily view in which the smart home and the inhabitants' events are each displayed in their own columns. All smart home events include two pictograms. One displays the cause of a triggered rule (such as a certain level of brightness or time of the day) and another pictogram shows the corresponding effect (such as shades going down or the heat turning on). The event can also be clicked to access an additional textual description (see Figure 6).

Evaluation process. We evaluated the prototype using expert walkthroughs [9] with four HCI researchers who were instructed to adopt personas that we developed based on our previous studies. The experts used the interface on a touchscreen to complete simple tasks (e.g., navigating through the interface, retrieving information about specific smart home events). To achieve interaction conditions similar to wall calendars and match the size of calendars we found in

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[5] https://github.com/robmonie/

participants' households for our study setup, we used a 20" tablet device (see Figure 7).

Key findings. We identified some interface usability issues, mainly regarding the touch gestures used, and observed that participants liked drawing connections between personal events and the smart home's events. The proposed visualization of smart home events as calendar events was well understood and seemed to match with the existing mental models of calendar tools. However, this is just a preliminary indication of the applicability of this metaphor as the interface content was still simple compared to a complex smart home system. Participants also expressed interest in having more options to change the visualized events; this finding is especially encouraging given that passive users in our previous studies had expressed little interest in control or configuration. This may be an indication that simple visualizations promote interest in engaging with smart homes.

Future Work
Currently, we are integrating the interface prototype with a commercially available smart home solution. We chose a standard solution in order to be able to deploy Casalendar into households that already have advanced building technologies installed, and to minimize novelty effects in participants. We are also exploring further opportunities for a more meaningful integration between inhabitants' personal calendars and the calendar of a smart home as well as integrating options to edit and create smart home events.

By extending and iterating on the existing prototype we aim to develop a prototype suitable for real-world deployment. This will allow us to learn whether it

encourages active participation in smart home control, and provide further insights into how temporal metaphors can support the smart home experience.

Acknowledgements

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Figure 8: Screenshot of our current interactive prototype for Casalendar