Towards Notifications in the Era of the Internet of Things

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ABSTRACT
Today, the smartphone is the main device for notifying the user, for example, about incoming messages or upcoming appointments. However, we envision that in the near future Internet of Things (IoT) devices will become an additional source of notifications. The resulting increase in notifications needs to be tackled to allow users to perceive all notifications without overloading them. In this paper, we report on two focus groups exploring how notifications in the era of the Internet of Things could be visualized. We derive design implications from the results of the focus groups which could influence how in the future smart devices notify users.

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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Notifications; Internet of Things; Smart Home

INTRODUCTION
Notifications are one of the core functionalities of nowadays mobile devices. They inform the user on incoming messages, upcoming appointments, and upcoming software updates [4]. The number of notifications the users have to deal with is constantly increasing over the last years. This is caused by more and more applications generating notifications and, thus, trying to catch the attention of the user. Nowadays, the notifications which are shown on the devices are originally generated on the same device. In the future, however, IoT devices (e.g., a smart heating or plant container) will also create notifications and inform the user about their current status or prompt actions which the user should do (e.g., reduce heating or watering the plant). These notifications will most likely be shown on the user's smartphone. However, this will lead into a information overload because the users will receive too many notifications.

We propose displaying these notifications not only on the smartphone but in the environment (see Figure 1). Using the environment for communicating information to the user has already been explored, for example, by using ambient light information system in an office environment [3], an ambient orb to display text messages [1], or the TV as central notification display [7]. All these projects, however, focus mainly on displaying notifications similar to the ones generated on smartphones and bringing them into the environment. In contrast, we focus on notifications which are generated in the environment itself (e.g., through sensors attached to plants, heatings, or in furniture). Thereby we explore how the sending device of the notification and the location at which the notification is displayed can be linked and how the notifications can be visualized to implicitly conveying the content. In this work, we report on two focus groups and derive design implications for future notification systems.

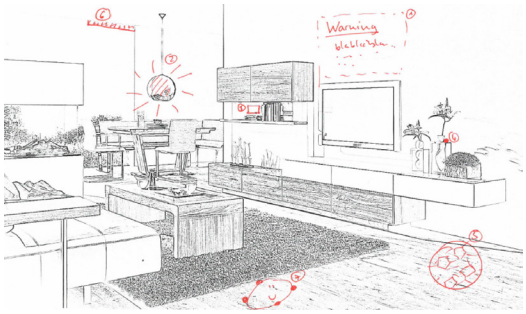

Figure 1. One of the worksheet used in the focus groups showing a living-room setting and the drawings made by a participant.

FOCUS GROUP
We conducted two focus groups with 6 participants each. The main task of each focus group was collecting ideas of how notifications generated by smart devices can be visualized in the environment. The participants were aged 18 to 28 years ($M = 24.4$, $SD = 2.93$) and recruited through University's mailing lists. Each focus group involved two main tasks. First, we collected different devices that could produce notifications in the future. Second, the participants draw on design sketches of different rooms (cf., Figure 1) how notifications could be visualized and where they could be located.

Output Methodology
Visual Output: The participants mainly mentioned visual cues due to their ambient characteristics. Visual cues included for example projection on arbitrary surfaces (e.g., projecting appointments), light installations (e.g., umbrella gets illuminated if the user should take it), and using smart devices such as TVs or controllable lamps (e.g., as a reminder).

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Haptic Output: Participants also mentioned haptic output. In contrast to on-body haptic feedback for notifying users [5], they mainly focused on feedback in smart objects. For example, the participant suggested that the sofa starts vibrating as a reminder to go to an appointment.

Auditory Output: Most participants did not mentioned auditory output except for urgent scenarios (e.g., Pizza needs to get out of the oven). They argued that auditory output would be disturbing with an increasing number of notifications.

Output Location

Central Notification Area: Participants mentioned using a single notification screen for general purpose notifications. This could be either a dedicated display or a smart TV. The participants mentioned mainly examples that focus on reminding the user. For instance, they mentioned using a digital picture frame that lights up and/or shows a picture of a person you planned to visit as a reminder.

On-Object Notifications: Placing notifications directly on the object generating the notification has been mentioned since the spatial relation supports the understanding of the notification. Many smart devices do not have dedicated output possibilities such as displays (e.g., hydrometer in a flower pot). Thus, a projection could be used to present information on the object [2]. Examples include displaying items on the fridge the user is running out (e.g., milk is almost empty) or an animation of water trickling on the plant to indicate the necessity of watering it.

Ambient Notification: Similar to the work of Müller et al. [3], participants mentioned several scenarios in which ambient notifications could be used. Particularly, for continuous notifications such as on energy or water consumption (e.g., change the color of the lighting slightly to red indicating high consumption). Another example mentioned was that reducing the illumination could indicate that users should go to sleep or change all lighting to a red color to notify on an emergency.

Visualization Type

Textual: Textual notifications presented content similar to current notifications on the smartphone. Participant, for example, mentioned "water missing" projected next to a plant to notify the user on watering the plant. Another example was showing a receipt next to the oven in the kitchen.

Color-coded: Abstract notification include highlighting a plant red to indicate that the user needs to water the plant or coloring the door in a light red or green based on whether it is locked or not. These visualizations could be realized with LED integrated into the environment.

Symbolic: Participants also mentioned symbolic visualizations in which the action that is required by the user is shown by the notification. Symbolical visualizations required projection and sophisticated design but yield the advantage of being potentially easy to understandable. Example include projecting on a plant in way that the leaves look like they are almost toasted to remind the user to water the plant. Another example would be visualizing rain over the plant to indicate the absence of water.

IMPLICATIONS FOR FUTURE NOTIFICATION SYSTEMS

Allow Multimedia Content: Using animations (e.g., rain or rising warm air) was mentioned in both focus groups. Additionally, using a specific color was one of the most mentioned ways to notify the user (e.g., at the door or in the whole room).

Different Feedback Locations: Participant chose different locations for different types of notifications. Participants draw particularly notification that are not urgent on the creator of the notification (e.g., the plant if a sensor sensed a lack of water). This result is in-line with the work of Voit et al. [6].

Reduce Overload by Unobtrusiveness: None of the participant explicitly was in favor of auditory cues. While current notifications are rather obtrusive, notification for smart devices may overload the user due to the sheer number of potential notifications. Thus, many of the notification visualizations created during the focus group involved visual cues that weave themselves into the environment.

CONCLUSION

In this paper we reported on two focus groups we conducted to explore how notifications could be visualized in the era of the internet of things. We group the results of the focus groups based on three topics and derived design implications. This work outlines challenges designer and developer of IoT systems will face in the future when creating notifications for their smart devices.

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