A Multi-Display System for Deploying and Controlling Home Automation

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Abstract
In this paper, we present a concept of using a home devices mashup tool to wire home devices on a tabletop display in combination with web based UIs on mobile devices to control home devices. This concept is realized by a multi-display system supported by the open-source framework *Environs*. The mashup tool on the tabletop enables multiple people to deploy home networked devices co-located collaboratively with a more natural and intuitive interface. Moreover, web based UIs on mobile devices enable individuals to control home devices universally with high accessibility and mobility.

Author Keywords
Internet of Things; Networked devices; Multi-display environment; Tabletop; Mobile devices

ACM Classification Keywords
H.5.2 [User Interfaces]: User interface management systems (UIMS).

Introduction
Home automation is featured by connected home appliances and automatic awareness of the surrounding environment employing the Internet of Things (IoT) technology. Within recent years, the IoT technology has increased the available networked and intelligent devices

for such home appliances, such as Nest Learning Thermostat [1], Philips Hue Connected Bulb [2], or Smart TVs. However, due to heterogeneity of platforms and diversity of home device controllers, deploying and controlling home networked devices is still cumbersome. The emergence of IoT mashup tools, such as ClickScript [3], or WotKit [4], enable people to connect devices and compose services to create IoT applications by means of a web based graphical editor. However, these tools are designed for PCs which do not offer the advantages of horizontal tabletop displays, such as co-located collaborative or natural interaction, or a large design space. Therefore, we intend to combine a visual mashup tool with a tabletop display to wire home devices. Thereby, enable people to deploy home networked devices collaboratively with less effort. Furthermore, current home appliances require people to use different controllers to interact with home devices. Our concept replaces those controllers with familiar and personal mobile devices, such as smartphones or tablets, which play as universal controllers for the home networked devices.

This paper describes a concept build on top of a multi-display system consisting of a tabletop display and mobile devices. The tabletop shows a visual mashup tool for deploying home networked devices whereas the mobile devices make use of web based UIs for controlling a particular home device. The system aims to assist end users to create personalized home automation easily and to control home devices universally using their mobile device.

Related Works

In the light of this paper's aim, several researchers investigated the idea of using mobile devices to control home appliances. Suo et al. [11] showed the system House Genie to control and monitor home networked devices on smartphones universally. Nichols et al. [8] presented Huddle which can generate task-based UIs on handheld devices for controlling multiple connected home appliances. Pan et al. [9] demonstrated a handheld device called GeeAirfor which can control home appliances remotely through multimodal interaction using gestures, physical buttons, speech, and light. However, the usability of these existing works is restricted by limited design space of mobile devices, especially when people wire devices to deploy home automation. Moreover, they do not support multiple people to work collaboratively.

In fact, several research projects have investigated the usage of visual tools for end users to deploy and control home automation. The interactive home network management system *Eden* [12] helps people understand how a home network works and configure network and networked devices intuitively. The application OSCAR [7] supports end users to monitor and manipulate connected devices, wherein people can save reusable configurations for frequent activities. Despite the benefits of these tools for home automation, so far there is still no one proper platform to support multiple people to wire home devices conveniently and collaboratively, i.e. on a tabletop surface. Kim et al. [6] presented an *Ambient Wall* interface to monitor and control surrounding home devices by simple gestures, but the workload of building such a system is not trivial.

Seifried et al. [10] showed the system CRISTAL which uses a tabletop display to enable gestural interaction on video images of the surrounding environment. It supports multiple people to control home devices and media universally. However, controlling home devices only on a tabletop display may be restricted by its limited mobility.

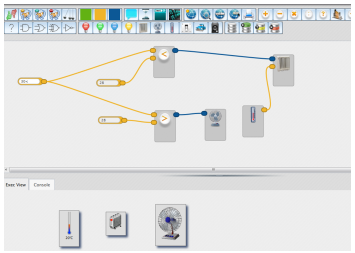

Figure 1: An example of a home heating system in ClickScript.

Figure 2: UIs of home devices on mobile devices.

The Concept of our System

Our system enables multiple people to manage and control home networked devices in a multi-display environment comprised of mobile devices and a tabletop display. To be specific, this system provides the following features:

- It enables multiple people to deploy home networked devices collaboratively on a tabletop display.
- It allows people to interact with a particular home device through their mobile devices.
- It supports people to interact with home devices via more natural and intuitive touch-enabled user interfaces.
- It is based on a multi-display environment with high responsiveness through low latency communication between the components.

System Architecture

The tabletop display shows a visual mashup tool for managing networked devices, whereas mobile devices present web based user interfaces for controlling home devices as sketched in Figure 3.

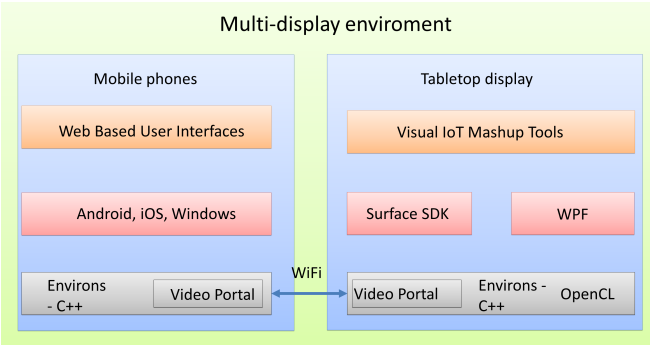

Figure 3: Multi-display system architecture.

In order to achieve low latency communication and a responsive system, our system makes use of the open-source framework *Environs* [5], which is a multi-platform software framework that enables spanning of heterogeneous multi-display environments. We use this framework to span an application environment that includes the tabletop and mobile devices in order to extend the possibilities of the tabletop application and co-located interactions with mobile devices. All participating devices in the environment are automatically identified and managed by the framework which enables mobile devices to participate in an ad-hoc way.

Furthermore, the framework enables interactive video portals between devices where touch-input on the mobile device is put through to the tabletop application and happens there in realtime. By this way, users are able to manipulate the mashup tool on the tabletop using their mobile devices. Our system thereby allows managing and controlling of the home networked devices through mobile devices and the tabletop application at the same time.

Tasks of Deployment and Control

Our concept focuses on two tasks that occur in deploying of home automation. One of the tasks is to manage connections between physical devices through visual mashup tools as exemplarily depicted in Figure 1 for ClickScript. In our system, such an application runs on the tabletop display allowing people to plan and connect home devices together by means of prevalent and familiar direct touch manipulations.

The other task is to control a particular device via its user interface which is realized in our system by providing web-based UIs of the home devices on users' mobile devices, for example as sketched in Figure 2.

Figure 4: A mobile tablet placed on the air conditioner icon, whereupon the UI of the air conditioner is shown on the mobile tablet.

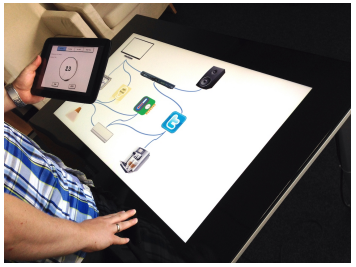

Figure 5: The user controls the air conditioner by means of the mobile tablet.

Users who want to control a specific home device either select the particular device on the mobile device or put the mobile on or near to the particular device's icon in the visual mashup tool on the tabletop display, see Figure 4.

In our setup, each mobile device has a visual marker mounted at the bottom-side which enables the tabletop to detect and identify the mobile device on the tabletop surface. Upon placement of the mobile device, the tabletop creates an interactive video portal to the mobile device in order to visually replicate the tabletop area covered by the mobile device. This video portal allows users to open the user interface of a home networked device on their mobile device by touching on the particular icon. Afterwards, the mobile device keeps showing the user interface even if it is lift off from the tabletop display, thus people can control the home devices from mobile devices anywhere, see Figure 5.

Conclusion

In this paper, we presented a concept of a system to control home networked devices in a multi-display environment. Tabletop displays and mobile devices are used to manage and control home networked devices collaboratively and conveniently. Future works include the design and implementation of a visual mashup tool for the tabletop display and web-based UIs for home networked devices in order to conduct research regarding useable UI designs or guidelines for tabletop mashup tools, or appropriate interaction techniques for collaborative or synchronized manipulations.

Acknowledgments

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References

[1] https://nest.com/.
[2] http://www2.meethue.com/.
[3] http://clickscript.ch/.
[4] Blackstock, M., and Lea, R. Wotkit: a lightweight toolkit for the web of things. In *Proc. of WoT*,
[5] Dang, C. T., and André, E. A framework for the development of multi-display environment applications supporting interactive real-time portals. In *Proc. of EICS*, ACM Press (2014), 45–54.
[6] Kim, H., Jeong, K., Kim, S., and Han, T. Ambient wall: Smart wall display interface which can be controlled by simple gesture for smart home. In *Proc. of SIGGRAPH Asia*,
[7] Newman, M. W., Elliott, A., and Smith, T. F. Providing an integrated user experience of networked media, devices, and services through end-user composition. In *Pervasive Computing*. Springer.
[8] Nichols, J., Rothrock, B., Chau, D. H., and Myers, B. A. Huddle: automatically generating interfaces for systems of multiple connected appliances. In *Proc. of UIST*,
[9] Pan, G., Wu, J., Zhang, D., Wu, Z., Yang, Y., and Li, S. Geeair: a universal multimodal remote control device for home appliances. *Pers Ubiquit Comput*.
[10] Seifried, T., Haller, M., Scott, S. D., Perteneder, F., Rendl, C., Sakamoto, D., and Inami, M. Cristal: a collaborative home media and device controller based on a multi-touch display. In *Proc. of ITS*,
[11] Suo, Y., Wu, C., Qin, Y., Yu, C., Zhong, Y., and Shi, Y. Housegenie: Universal monitor and controller of networked devices on touchscreen phone in smart home. In *Proc. of UIC-ATC*,
[12] Yang, J., Edwards, W. K., and Haslem, D. Eden: supporting home network management through interactive visual tools. In *Proc. of UIST*,