Experiencing Tangible Privacy Control for Smart Homes with PriKey

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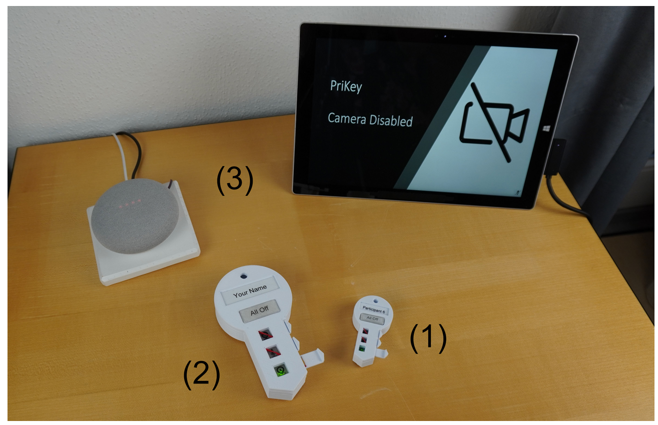
(a) The Wizard-of-Oz tangibles illustrate the envisioned size and portability. The depicted tangible is configured to allow only video recordings. The all off button can be used to turn off all sensors.



(b) Demonstration setup: (1) the Wizard-of-Oz tangibles, (2) a larger functional prototype, and (3) sample smart home devices (i.e., a smart speaker and a tablet with a webcam).

Figure 1: We present *PriKey-Demo*, a demonstration that allows to experience tangible privacy control for smart homes. *PriKey* enables both inhabitants and visitors of smart homes to execute their privacy choices in an intuitive and direct manner.

ABSTRACT

Existing software-based smart home privacy mechanisms are frequently indirect and cumbersome to use. We developed *PriKey*, a tangible privacy mechanism for smart homes that offers intuitive, device-independent, sensor-based, and user-centric privacy control. To render our concept comprehensible, we implemented a demonstration consisting of Wizard-of-Oz prototypes that show the envisioned form factor, size, and portability of our system, as well as a larger functional prototype of *PriKey*, which enables control of privacy-invasive sensors integrated into two exemplary smart devices, i.e., a smart speaker and a tablet.

CCS CONCEPTS

• **Security and privacy** → **Usability in security and privacy**; • **Human-centered computing** → *Ubiquitous and mobile devices.*

KEYWORDS

smart home, privacy, tangible, tangible privacy, bystander

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1 INTRODUCTION

Sensor-enhanced smart devices have been increasingly adopted in private households, potentially collecting sensitive data about people in their surroundings, e.g., recording audio, video, or presence.

However, affected individuals – especially if they do not own the smart home devices themselves – are frequently unable to assess whether and to what extent nearby devices put their privacy at risk [8, 10]. In particular, non-owners (e.g., visitors or co-inhabitants of smart homes) can usually not exercise control over the devices and thus are unable to protect their privacy [3, 4]. Moreover, existing smart home privacy mechanisms are frequently integrated into screen-based multi-purpose devices, making the interaction with them non-engaging, indirect, and cumbersome [6, 7]. To address these issues, researchers proposed the development of *tangible privacy mechanisms* that provide intuitive, unambiguous, and direct ways to protect one's privacy [1, 5, 7, 9]. However, many of these suggestions are purely conceptual [1, 7], and actual implementations of tangible privacy mechanisms are still scarce [2]. We built upon these conceptual suggestions and developed *PriKey*, a concept for tangible privacy control that supports everybody within, e.g., a smart home with equal means of protecting their privacy [9]. In a next step, we developed a functional prototype of *PriKey*, which allows us to present our approach on *tangible privacy control for smart homes* in a simple and portable manner. This demonstration consists of a) Wizard-of-Oz prototypes that illustrate the envisioned size and portability of *PriKey* and b) a functional setup demonstrating the effects of *PriKey*'s privacy settings on (sample) smart home devices. While we used the Wizard-of-Oz prototypes to conduct the previously published studies [9], the functional setup is novel and has not been published before.

2 PRIKEY CONCEPT

PriKey is a concept for *tangible privacy control* in smart home contexts [9]. In particular, *PriKey* enables smart home inhabitants and visitors to communicate and execute their privacy choices. It applies privacy settings to all devices in the users' surroundings, regardless of quantity and precise location. *PriKey* groups different privacy choices by the type of sensor. Users can choose to allow or reject all video (), audio (), or presence () recordings of nearby devices independently. Hence, *PriKey* reduces complexity by enabling device-independent, sensor-based and user-centric privacy control. More details on our concept can be found in our paper [9].

3 DEMONSTRATION

The demonstration of *PriKey* is two-fold: 1) The envisioned size, lightweight, and ease of portability of *PriKey* can be perceived through the Wizard-of-Oz tangibles; 2) *PriKey*'s functionalities can be observed when interacting with the fully functional setup.

3.1 Wizard-Of-Oz Tangibles

The Wizard-of-Oz tangibles are small 3D printed key-shaped objects (75mm length x 40mm width and 17mm height, see Figure 1a). They each incorporate an Attiny84A microcontroller, a 3.3 V coin cell battery as well as one LED and one key-teeth switch for each sensor type (i.e., video, audio, and presence). Users can configure their privacy choices by enabling or disabling each sensor type independently by moving the corresponding switch out (sensor on) or in (sensor off). The LEDs of each sensor turn on to visualize if a sensor-type is collecting data or turn off to indicate the contrary. Further, the tangibles include an "All Off" button which turns all sensors immediately off (all LEDs turn off) independent of the previous settings represented by the key-teeth switches.

The Wizard-of-Oz prototypes do not provide any functionalities other than turning their LEDs on and off to simulate the states of the different sensor types. However, they represent the form factor and size we envisioned for *PriKey*, while being easily reproducible, robust, compact, and lightweight. Thus, they reflect important aspects of our concept and were used for the evaluation presented in our previously published paper [9].

3.2 Functional Prototype

To further showcase the functionality of *PriKey*, we developed a setup that consists of a) a functional but larger key-shaped tangible, called *Maxi-PriKey*, and b) two exemplary smart home devices (i.e., a modified smart speaker and a tablet with an incorporated webcam, see Figure 1b).

3.2.1 *Maxi-PriKey.*

Maxi-PriKey has the same shape as the Wizard-of-Oz prototypes, with larger dimensions (150mm length x 80mm width and 27mm height). This allowed us to incorporate the electronics necessary to provide wireless networking capabilities. Hence, *Maxi-PriKey* incorporates an ESP8266 microcontroller with integrated WiFi capabilities, a corresponding battery shield, and a rechargeable 3.7 V Lithium battery. We implemented a web server on the microcontroller that communicates the current privacy settings configured on the *Maxi-PriKey*.

3.2.2 *Sample Smart Devices.*

We included two exemplary smart home devices into our demonstration setup: a Google Nest smart speaker[1] as a representative for audio recorders, and a Microsoft Surface[2] tablet as a representative for video and audio recorders.

By carefully opening the smart speaker, we were able to highjack the incorporated mute button and connect it to a WiFi-enabled microcontroller (ESP32). As a result, we could (un)mute the smart speaker's microphone via the microcontroller. We implemented a web client on the ESP32 that pulled the current *Maxi-PriKey*-supported privacy configurations using HTTP-GET requests.

We further developed a Processing[3] application on the tablet that shows a live stream of its webcam. The application includes a similar web client and, thus, reacts to privacy settings being changed by visualizing either the live stream of the webcam (i.e., video recordings are enabled on the *Maxi-PriKey*) or a screen informing the user that the webcam was turned off. The application further indicates the current state of the microphone via an icon (crossed out microphone if the audio recording is disabled).

4 CONCLUSION

In our previously published paper, we developed *PriKey*, a concept for intuitive tangible privacy control for smart homes. In this demonstration, we present a) Wizard-of-Oz prototypes showing the

[1]https://store.google.com/de/product/google_nest_mini, last accessed September 2022
[2]https://www.microsoft.com/de-de/surface, last accessed September 2022
[3]https://processing.org/, last accessed September 2022

envisioned form factor, size, and weight, as well as b) a setup that allows testing the functionality of *PriKey*. Our demonstration enables the audience of MUM'22 to experience *tangible privacy control for smart homes*. We hope to trigger vivid discussions on *tangible privacy mechanisms* for smart homes, but also for other contexts such as public (e.g., malls) or semi-public spaces (e.g., workplaces).

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