

## Title: Understanding and Improving Security and Privacy in Multi-User Smart Homes: A design Exploration and In-Home User Study

Smart Homes are fundamentally multi-user platforms. Multiple people living in or accessing a home may want or need the ability to use and configure smart devices within the home. Platforms such as Samsung SmartThings, Philips Hue Lights, Google Home, Amazon Echo are being increasingly adopted and deployed. However, conflicts and tensions may arise between multiple stakeholders accessing Smart Home Applications even when relationship between people are not explicitly adversarial. Unfortunately, according to previous studies, current smart homes are not yet thoughtfully designed for interactions and use between multiple users. Prior work has developed an initial set of design principles such as: access control flexibility, user agency, respect among users and transparency of smart home behaviours. To evaluate how well these design principles, meet an in-situ user study was conducted. From the findings the question about how can smart homes designers increase the flexibility of access while making complexity manageable for all users was aroused. For Example- More tech-savvy users may have more access to device functionality and the power to restrict others from using the devices or Smart Homes can intentionally or unintentionally used to expose privacy sensitive information about one another. Many other types of access control policies that could also be used including time-based, location-based, per-user and per-device policies. However, adoption of these policies is limited and uneven. The authors have then analysed a hundred of participants and their result analysis aims to close the above-mentioned gap in this work. Towards meeting transparency in Smart Homes, notifications that alert users when the states of home devices change were designed. Another challenge of 'user agency' was solved by designing persistent notification of nearby devices without needing to open the Apps. This prototype was connected to devices via the Samsung SmartThings API. A qualitative data about previous experiences with Smart Homes and feedback on the new prototype was collected. This survey brought about new challenges like Location Restrictions for Visitors, Configuration changes Prevention, Parental Control, Private room devices, Inference with other devices, Quick Access, some Installation barriers and more which are very well addressed in the paper. The finding suggests that there are many user goals which can be handled using access control but only a few specific are suited. Also, some participants didn't experience multi-user conflicts and privacy problems due to the norms of interpersonal rules in their home itself. Based on all the insights some principles suggested by the author were revisited. Based on the findings and revised design principles, the authors have then suggested several design recommendations as mentioned-

1. Support Smart Home-Specific Access Control Needs.
2. Simplify Access Control Configuration.
3. Incorporate voice assistants into Access Control Systems.
4. Reduce User Onboarding Barrier.

Future work to investigate on this topic suggested by the author includes how to design Smart Home access controls and monitoring that it protects user's privacy. Surfacing information about when audio and video is being recorded or viewed like voice assistants or security cameras could change user's perception of privacy risks of these devices. A possible way to simplify configuration is to allow users craft their own policies using a controlled natural language interfacing rather than menus with drop-down list and checkboxes. This study nevertheless comes with several limitations too. Since it required consent from all participating household members the sample is skewed towards members who are sufficiently agree to participate together in study(cooperative). Future work should further consider multiuser Smart Home design in the face of more invasive devices. Finally, the complexity and cost of in-home study limited the feasible number of participating households, preventing us from drawing more quantitative conclusions. Despite the limitations, the study provides valuable insights to design multi-user Smart Homes security and privacy features.

With all the studying and analysis, the authors recommend that the researchers may improve usability of Smart Homes access control by developing more usable configuration interfaces and design platforms that will reduce tensions and conflicts by leveraging and scaffolding positive household norms.

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