



Fig. 2. Flow chart of the prototype for audio-based privacy aware notification system, implemented in an Alexa powered VUI device

assistant for the intended service or by other services as well.

D. Summary

The first user study showed that users are most concerned about privacy breaches concerning location tracking and private conversations. Furthermore, we learned the main privacy expectations of users for human-to-VUI interaction: 1) Require consent from the user when using private data. 2) Feature to forget the collected private data. (3) Feature to turn off the voice assistant. (4) Private data collected by the voice assistant can be used for positive purposes only. In addition, we investigated and identified expected notification modalities in different contexts: 1) Users mostly prefer visual and application-based privacy notifications when interacting with their own voice assistant. 2) Users prefer audio and application-based privacy notification while interacting with classmate’s voice assistant. Lastly, based on the responses from the user study, we implemented and evaluated the prototype for an audio-based privacy aware notification system to validate our conclusions of the preferred notification modalities.

Evaluation of the prototype shows that the implemented audio and beep notifications are helpful, noticeable, and necessary to draw attention of the user.

While the results presented in this paper aids in advancing the discussion on privacy awareness in VUI devices, we propose some improvements which can further elevate the findings. The user study in this work was conducted in a lab settings with limited number of participants. Hence, we need to scale up the user research with more participants, to obtain statistically significant results. Furthermore, we could add another dimension to the qualitative analysis by critically relating the behavior and non-verbal expressions with the spoken words during interviews. To categorize and analyze the emotional experiences of a user, we have used Plutchik’s wheel of emotions, which defines four primary emotions: joy, trust, fear, and surprise [20]. In order to obtain more granularity in understanding the emotional experiences and expectations, an additional analysis method could prove beneficial. The potential improvements of the current work are left for future investigations.

IV. CONCLUSION

Through the results presented in this work, we hope to have advanced the discussion on *privacy awareness of VUI devices*. By conducting user studies, and qualitative and quantitative analysis of the data, we present the findings on emotional experiences and privacy expectations of a user in a human-to-VUI interaction. The analysis shows that people are most concerned about privacy with respect to location tracking and listening to private conversations. We also discover the privacy expectations of a user from a voice assistant; they are: 1) a voice assistant should take consent for the usage of private data, 2) a voice assistant should have a feature to forget private data from users, 3) a voice assistant should support a feature to turn off the voice assistant, and 4) a voice assistant should only use the collected private data for positive purposes. Furthermore, we identify the user preferences for privacy notification modalities, with respect to different contexts. The results presented in this paper can be employed to design privacy-aware VUI devices, whereby user experiences and expectations can be modelled to allow the VUI devices to naturally adapt to the varying privacy requirements of the users without explicit user intervention.

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