SSH – Automated Task and Activity Recommendation Feature

Engineering Design Review

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Introduction

For the last three months, we have focused on resolving the issues that students frequently encounter in shared housing to further meet their needs and wellbeing. The most common housemate problem, highlighted by the 2024 National Student Accommodation survey, was leaving dirty dishes out (65%). The second most common issue was housemates not helping with cleaning (55%).

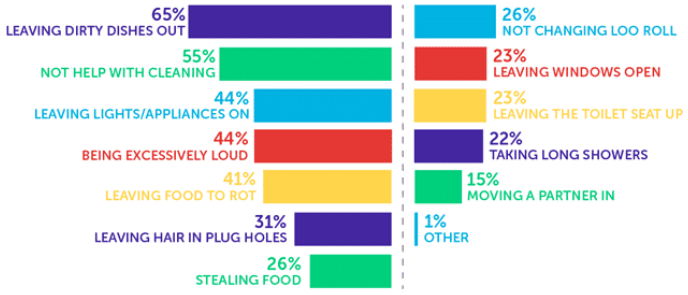

Figure 1: Most common problems with housemates (taken from the National Student Accommodation Survey 2024)

After the most recent update, we have addressed the most common issue of housemates leaving dirty dishes out. The SSH Cameras can now detect who leaves their dirty dishes in the sink so that SSH Cloud will then automatically send notifications to the SSH App to remind those housemates to clean up.

We believe we can build on this feature by developing a new task and activity recommendation feature. Using occupancy trends over time that are available from the data collected by the SSH Cameras, the new feature will be able to automatically suggest times during the week when it may be convenient for a given student to carry out tasks, such as cleaning their dishes or taking out the bins, because they are typically at home. Conversely, it may also suggest activities, such as making use of the TV or the gaming console because all or most other members of the household are typically away.

Adding such a feature to the existing ecosystem is invaluable as it will help reduce the friction felt between students living in shared accommodations, while also encouraging them to build positive habits. This design aligns with our commitment to supporting students holistically and ensuring that their living environment contributes to a fulfilling university experience.

Goals and non-goals

- **Goal:** Analyse existing data from SSH Cameras to create occupancy trend reports for each student in a household.

- **Goal:** Send out automated notifications via the SSH app based on occupancy trends with recommended times to complete tasks or activities. We aim to achieve a task completion rate of 60% amongst students, after the first year of release, to measure the usefulness of this feature.
- **Non-goal:** Integration with other personal calendar applications (e.g. Google Calendars).
- **Non-goal:** Custom task creation.
- **Non-goal:** Behavioural tracking for automatic task completion.

Design Overview

The new task and activity recommendation feature will be implemented through SSH app and the SSH Cloud. Students will receive automated app notifications on their personal devices with task or activity recommendations based on their personal routines and those of their housemates.

The system predicts when a student is most likely to be at home based on historical occupancy data collected by the SSH Cameras. The cameras are equipped with facial recognition AI, enabling them to identify each student and monitor their presence in a household. When a student leaves or arrives home, the SSH Cameras trigger an event, automatically sending over real-time occupancy data to the backend server via the MQTT (Message Queuing Telemetry Transport) system. The data consists of the following information:

- Student ID (Existing unique identifier)
- Event type ("Arrived home", "Left home")
- Timestamp (Time student arrived or left home)

A central database in the SSH Cloud stores this occupancy data. Each student's entry or exit event is logged in a table automatically through our DBMS (database management system), creating a historical record of when each student was at home or away.

From here, we analyse time trends for each student by feeding the data into a trained AI model. The AI model will generate a report for each student, summarising times they are usually at home or away. Based on an individual's generated report and comparing them to housemates' reports, the AI model will suggest suitable times to carry out pre-determined tasks or activities. Some pre-defined tasks and activities include:

- Taking out the bins
- Washing the dishes
- Cooking
- Laundry
- Cleaning the kitchen
- Cleaning the bathrooms
- Using the TV
- Using the gaming console

Students can choose which notifications they receive for specific tasks and activities within the SSH app, personalising the recommendations they receive. The AI model will take these

preferences into consideration and map the relevant pre-defined activities or tasks to the most suitable time slots on their report.

The task and activity recommendations, along with the historical occupancy data, are stored in the same database within the SSH Cloud for ease of integration and querying.

While the system primarily relies on historical trends to make suggestions, we use real-time occupancy data as a fallback mechanism. For example, if a student is home when they were predicted to be away, the system adjusts its recommendations based on actual student presence. Similarly, if housemates arrive home unexpectedly when they were predicted to be away, the system adjusts and avoids suggesting the use of shared spaces and appliances during this time.

We send push notifications to students with the recommendations through the FCM (Firebase Cloud Messaging) system. Clicking on the notification directs them to a task management page within the app's UI. This page is updated in real time using WebSockets, which are already integrated into the app's architecture. Students can examine their recommendation history within this page, with the ability to also mark any tasks or activities as complete. As a short cut, students may also click on the notification drop-down and mark tasks or activities as completed without needing to go into the app.

Once marked as complete, task and activity completion times are stored in the backend and fed back into the AI model. The model uses this data to learn from student behaviour over time, refining future recommendations to better fit an individual's routine.

Alternatives considered

Room-level occupancy and behavioural tracking

An alternative to relying on general student presence to generate recommendations is to use the SSH Cameras to track students' exact locations within their house. For example, if the cameras detect when a given student is in the kitchen, the system may suggest that they wash their dishes. Similarly, if the cameras detect that a student's housemate is already cooking in the kitchen, the system will avoid recommending using the kitchen during this time.

Additionally, the system could implement behavioural tracking to detect when tasks are completed. For example, if the cameras can detect when a student has taken out the bins, it will automatically mark the task as complete in the system.

- *Pro*: More precise task recommendations based on students' physical locations - improves timeliness and usefulness of recommendations.
- *Pro*: Automated task completion tracking – reduces the need for manual updates, useful for those who forget to mark off tasks as complete.
- *Con*: Privacy concerns – Constant monitoring of students' behaviours and specific locations in the house may be perceived as intrusive, leading to discomfort amongst some users.

- *Con*: Increased complexity and cost – The SSH Cameras are currently only able to track several behaviours (e.g. detecting who is at home, who has washed the dishes, who's taken an item from the fridge). If we were to implement the behavioural tracking system for all task and activity types, this would require extra resource investment into the SSH Camera's AI, increasing the technical cost and complexity of the system.

Custom-task creation by students

A potential add-on feature would enable students to create their own tasks in the app, offering more flexibility and personalisation beyond the pre-defined tasks established by our team. This could foster greater user engagement as students feel more ownership over the system.

However, custom tasks may not align well with the initial AI model. Moreover, this add-on will require a more sophisticated UI and backend logic to handle user-defined inputs. Consequently, for now, we assume that this could be implemented in the future after monitoring the initial release of the task recommendation feature.

Console table task recommendation integration

Currently, the SSH console table allows students to manually arrange rotas for shared household tasks. By integrating the task recommendation feature into the console, this process could be automated, reducing the need for manual coordination between students. However, because the console table is sold separately and is not necessarily present in every student home, we assume that this will be an option available in the future for students with access, after the initial release of this feature.

Milestones

Milestone 1: Confirm the structure of the database schemas and make sure the current MQTT system is functioning as intended. We can move forward if real-time data is stored without issues and flows smoothly to the backend.

Milestone 2: Focus on developing and training the new AI model using historical occupancy data. This step enables the model to produce occupancy reports and suggest initial tasks. We then check if the recommendations are relevant and accurate. If the results are not satisfactory, we will reassess and decide whether to pause or further refine the model.

Milestone 3: Integrate the AI model into the broader task recommendation engine and incorporate real-time data processing for the fallback mechanism. We will test scenarios where real-time data contradicts historical trends, ensuring that the system adapts accordingly (this will not be visible to users yet). Once we are confident in these adjustments, we may move forward.

Milestone 4a: Develop the task management UI. The mobile development team will need to ensure that the UI is intuitive and responsive, allowing students to easily manage their tasks. We can continue to the next step once it is proven to be user-friendly and updated in real-time.

Milestone 4b: Set up the feedback loop to capture user actions such as completing or dismissing tasks. This data will enhance the AI's suggestions through continuous learning. We may proceed once the feedback loop is proven to be effective.

Milestone 4c: Implement FCM to deliver task notifications. Ensure these notifications work correctly, allowing users to interact by completing tasks directly from the notification.

Milestone 5: Perform system tests to ensure functionality, performance, and security are up to standard, before beta testing.

Milestone 6a: Run a beta test with real users to collect feedback on system usability, task recommendations, UI/UX, and overall performance.

Milestone 6b: Analyse user feedback and performance data to improve the system pre-deployment. We will ask the localisation team to localise the UI and notifications before the full release.

Dependencies

- *Mobile Development Team*: Will need to design the new task management page in the app's UI, ensuring it supports real-time updates and user-interactions.
- *Backend Engineering Team*: Will need to maintain the backend infrastructure that handles data collection from the MQTT system, as well as managing the task recommendation engine with the integrated AI model.
- *AI Team*: Responsible for developing and refining the AI model.
- *Cybersecurity Team*: Will need to ensure that personal occupancy data is handled securely. Will need to manage encryption, access control, and risk mitigation for data breaches.
- *Cloud Infrastructure Team*: Will manage the cloud infrastructure, scaling and uptime, and resource allocation to ensure the system runs smoothly.
- *DevOps Team*: Will manage continuous integration and deployment, automate testing, and monitor system performance post-launch.
- *Localisation Team*: Responsible for localising the app's UI and push notifications.
- *Legal Team*: Will need to review the legal aspects of data collection and processing around this project, updating our consent forms accordingly.

Cost

This new feature is expected to raise operation costs, with the predicted resource usage in the SSH Cloud being the most expensive component. The proposed design relies heavily on the cloud infrastructure for processing occupancy data, integrating the AI model, and sending notifications. As a result, the cloud will require greater processing power and storage to manage these new additions. Moreover, the initial training of the AI model and its continuous maintenance will require extra resource investment.

Privacy and security concerns

Although students previously consented to the collection of occupancy and facial recognition data, this data will be used for predictive analysis in the new task recommendation function. As a result, we will need to ask students for extra consent before using their data in this manner because it goes beyond the initial consent for monitoring

purposes. As such, a clear explanation of the data's intended use will be sent out to all students. An opt-out option will be available to those who do not wish to participate.

In terms of security issues, we must ensure that the cloud's occupancy data is stored safely, using encryption in-transit and at-rest. Regular security assessments and strict access controls will be required to reduce the risk of unauthorised access to occupancy data.

Risks

Risks	Impact	Mitigation(s)
Data privacy and security breach	High – Loss of user trust, legal penalties	Implement robust encryption, enforce access control, conduct security audits.
Overuse of cloud resources	Medium - Increased operational cost, potential system slowdowns	Optimize cloud resource allocation, implement monitoring tools, use data minimization techniques.
AI model inaccuracy	Medium - Inaccurate or irrelevant task recommendations, user dissatisfaction	Continuously train the AI model with real-world data and validate recommendations regularly.
Poor task adoption by students	Medium - Low user engagement, failure of the system to meet its intended purpose	Conduct beta testing, gather feedback, improve usability, implement a reward/ gamification feature.

Supporting Material

Brown, L. (2024) *National Student Accommodation Survey 2024 – results*, *Save the Student*. Available at: https://www.savethestudent.org/money/surveys/national-student-accommodation-survey-2024.html#key (Accessed: 27 October 2024).