Occupancy-Based Task Scheduling App in Student Smart Homes

Engineering Design Review

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Status: Draft

Introduction

Many students decide to live in accommodation. This puts lots of pressure on them, given it is their first time living alone combined with studying for their degree and potentially working a part time job, they struggle to organise their day-to-day life. It is therefore easy to see why many student accommodations end up becoming filthy with uncomfortable living conditions; stacks of washing left uncompleted and rubbish from the bins overflowing. At the same time, students in accommodation relax with their TV's and gaming consoles when they could be completing chores. This reduces the students' quality of life and causes stress, which in turn affects academic performance and wellbeing. In addition, some occupants of accommodations do more chores than others, creating friction between household members. While providers of student accommodation may feel that these issues are due to student laziness, we understand that students are new to adulting and caring for themselves, therefore they need guidance on how to structure their chores and balance it with their own recreation time.

We propose to create an occupancy-based task scheduling app (separate from the SSH app) that will use data from the SSH Camera to create schedules for occupants of a student accommodation by utilising occupancy trends. The main purpose of this app would be to send push notifications to occupants as to when it would be an ideal time for them to complete specific chores such as taking out the bins. Furthermore, this app would allow occupants to view a calendar showing every household members allocated timeslots for completing chores or recreation. Adding this app to the SSH ecosystem would appeal to providers of and students in student accommodations since it would ensure their accommodation is well maintained while taking organisational pressure off the occupants, therefore encouraging purchase of our SSH camera. To add to this, utilising The SSH Camera for this app makes it suitable for student accommodations, as it will ensure no permanent modifications are required.

Goals and non-goals

- **Goal**: Use occupancy logs from the SSH Camera at student accommodations to predict an appropriate chore and recreation schedule for occupants after a minimum of one week of data collection.
- **Goal**: Create an IOS and Android app that will display suggested chore and recreation schedules to students in accommodation as well as send push notifications when it is suggested they do a chore or enjoy recreation. We aim to see the app used by 50% of student accommodations with an SSH Camera.
- **Non-goal**: checking if students stick to their respective schedules.
- **Non-goal**: showing information to the landlords of student accommodations about their tenant's chore and recreation schedules.

Design Overview

The landing page for the occupancy-based task scheduling (OBTS) app will have a GUI that displays one of two things. If it is a user's first time opening the app or it's been 14 days since their last sign in, it will take them to the SSH account portal, providing the connection between them and the SSH cloud. Once logged in or otherwise, the app shows a calendar displaying every hour of that day and the names of the occupants at the student accommodation. A section of this can be seen below:

Table 1: Section of a Chore and Recreation Schedule

Monday

	7am	8am	9am	10am	11am	12pm	1pm
Tom	Watch TV	Watch TV	Out	Out	Out	Do dishes	Play video games
Ben	Out	Out	Out	Out	Out	Out	Out
Abby	Play video games	Play video games	Take out bins	Out	Out	Out	Out

In addition, the landing page will have a button that redirects users to a view of a calendar for the week, allowing them to navigate to a different day to check the suggested schedules for it.

Another feature of this app will be sending users push notifications 10 minutes before it is suggested they complete a specified chore or enjoy some recreation time. Users will be able to access a settings menu within the app to change notification settings, log out of their SSH account, or tweak the apps layout.

The suggested times for a student's chores or recreation will be calculated individually using time series analysis, given said individual has had their occupancy data recorded for at least one week. The suggested schedules will only consider the common waking hours of 7am to 7pm with each hour timeslot marked as either 'out', the name of a recreation activity, the name of a chore, or left blank. These are dictated in the following way for each hour timeslot on a given day using prior occupancy data (i.e. whether the student was in/out) for that day of the week:

1. If a student is out more than 70% of the time, mark the slot as 'out'.
2. If not, if they are in more than 70% of the time, the overall occupancy of the accommodation is greater than 40% on average at that timeslot, and the individual hasn't already been assigned 3 chores on that day, mark the slot as a random chore pulled from a list.
3. If not, if they are in more than 70% of the time mark the slot as a random recreation activity pulled from a list.
4. Otherwise leave the slot blank.

To calculate the percentage time that a student is in or out at a given timeslot we use the following formulas:

$$percentage\ in = \left(\frac{T_{in}}{T_{total}}\right) \times 100 \qquad\qquad percentage\ out = \left(\frac{T_{out}}{T_{total}}\right) \times 100$$

Where:

- T_{in} is the total number of times the student is marked as being in for the timeslot.
- T_{out} is the total number of times the student is marked as being out for the timeslot.
- T_{total} is the total number of days that the timeslot was considered.

Similarly, to calculate the percentage overall occupancy for a given timeslot, we use the following formula:

$$overall\ occupancy\ percentage = \frac{1}{n}\sum_{i=1}^{n}\left(\left(\frac{S_{(in)i}}{S_{(total)i}}\right) \times 100\right)$$

Where:

- S_{in} is the total number of students marked as being in for the given timeslot.
- S_{total} is the total number of students considered at the given timeslot.
- n is the total number of days considered.

This occupancy data is pulled from the existing daily CSV files produced by the SSH Camera, with a new file being created each day and sent to the SSH Cloud via the SSH Hub. Up to a years' worth of CSV files are stored in the OBTS app. These are returned from the SSH Clouds API, with the app making a GET request daily at 12:15AM using the current date to retrieve the relevant log. The resulting schedule is another CSV file saved locally within the app which is then displayed as a calendar in the format specified above.

Existing CSV files from SSH Camera

The SSH Camera already generates occupancy data for student accommodations as CSV files. The name of every CSV file is "occupancy_log_[DATE]" with [DATE] being the date the logs were recorded. This file is formatted with the titles in the first line of the file followed by their relevant fields below. Each title is broken down in the following table:

Table 2: Occupancy Log CSV File Description

Title	Description	Relevance
"student_id"	A 4-digit student identification number.	Used to retrieve the students name from the SSH Cloud as well as to link students to their respective chore and recreation schedule.
"7am-8am", "8am-9am", etc	Marked as True is a student is in and False if a student is out.	These are the timeslots used to calculate the percentage of times a student is in or out of their accommodation as well as overall occupancy.

Existing SSH Cloud Services

The SSH Cloud already has the infrastructure to handle GET request. In a GET request for occupancy logs, it takes in a date which retrieves the logs for that day, meaning the OBTS app can use the current date to retrieve a new occupancy log each day. These logs are sent to the SSH cloud from the SSH Hub which communicates with the SSH Camera.

In addition, the SSH Cloud provides the link between student's names and their student_id from occupancy logs CSV files. We already have the feature in the SSH Cloud that allows occupants of an accommodation to join a 'household'; a group of students living in the same accommodation. When a student logs into the OBTS app with their SSH login, it connects the app to the SSH cloud linking them to their assigned 'household'. The SSH Cloud will then automatically return a hash table to the OBTS app to link accommodations members ID numbers to their names by using student_id as a key and the students name as a value.

Alternatives

Producing chore and recreation schedules in the back end (SSH Cloud) instead of the front end (OBTS app)

Instead of producing a chore and recreation schedule in the OBTS app, we could instead produce this in the SSH Cloud, with the app requesting a new chore and recreation schedule daily instead of using the new occupancy data to produce its own schedule.

- *Pro* – the SSH Cloud is likely to have more computational efficiency than a smartphone and therefore could produce the schedule more efficiently.
- *Pro* – occupancy data is sensitive information and therefore keeping it on the SSH Cloud reduces the security risk of it being exposed to attackers.
- *Pro* – producing the schedule on the backend ensures all users get consistent results and reduces the risk of discrepancies on different students' smartphones.
- *Con* – the general SSH Cloud server load is increased.
- *Con* – retrieving the schedule from the SSH Cloud is less responsive than producing it in the OBTS app.
- *Con* – no offline capability for producing schedules.
- *Con* – since all OBTS app users would request updated schedules every day at the same time, it would create a large bottleneck on the SSH Cloud, making it difficult to scale the userbase with this implementation.

Alternative methods of calculating occupancy trends

There are many different methods of calculating occupancy trends. For example, we could use a clustering algorithm or a deep learning model. The issue with these approaches is that they prioritise complexity over utility, requiring significant data preparation and parameter tuning. To add to this, time series analysis is specifically designed for identifying trends making it the most suitable approach.

Alternative occupancy thresholds

Similarly, we could consider alternative occupancy thresholds for determining whether different slots of a student's chore and recreation schedule could be marked as 'out' or marked as a recreation slot. Instead, we will use the existing thresholds as a baseline and tweak them in the future if needed based on student feedback.

Milestones

Milestone 1a: Contact development team to begin development of a new program called TSA to handle the technical processes for creating chore and recreation schedules. Add, functionality such that given a list of CSV files and a hash table linking student_id numbers to names, a suggested chore and recreation schedule as a CSV file is returned by performing the specified time series analysis. This will allow us to implement the core process as efficiently as possible, with TSA later being utilised by the OBTS app.

Milestone 1b: Add the functionality to TSA to perform the GET request from the SSH Clouds API, returning an occupancy log using the current date. This allows us to test that interaction with the SSH Clouds API works as expected.

Milestone 2: Contact landlords of student accommodations that use the SSH Camera's on their properties and ask if their students consent to testing out the new functionality described in Milestone 1. If the students consent, a years' worth of occupancy data from their accommodations SSH Camera is inputted into TSA to produce a chore-reaction schedule. We

will use this to gain feedback on our model to see if the thresholds are suitable and students are happy overall with the schedule produced.

Milestone 3a: If we are successful in Milestone 2, allow the design team to create a suitable design for the OBTS app with the functionality specified in the design overview. We will demo the design to students in accommodations that use SSH technology.

Milestone 3b: Once settled on an appropriate design, the development team can implement it to create the OBTS app with TSA integrated in its backend.

Milestone 3c: Add the functionality to the OBTS app to perform the GET request from Milestone 1b daily and to send push notifications when it is suggested users complete a chore or enjoy recreation. We will now deploy the app in a beta phase for beta testing in student accommodations that use the SSH Camera, SSH Cloud, and SSH Hub.

Milestone 4: After beta testing has provided sufficient feedback that has been actioned, finish localisation of the apps text and notifications and perform a full release.

Dependencies

- *UI team*: Will need to plan and design the GUI for the OBTS app.
- *Development team*: Will need to create the TSA program and develop the OBTS app from the UI team's design.
- *Localisation team*: Will need to localise the finalised OBTS apps text and notifications.
- *Marketing team*: Will be responsible for reaching out to select landlords of student accommodations to ask for their help testing the functionality of TSA. They will also need to contact students about different designs from the UI team to gain their preference.
- *Configuration team*: Deploy the beta tests and full release.
- *Legal team*: Create appropriate terms and conditions for the new OBTS app to ensure we are not exposed to any liability.

Cost

We anticipate a moderate increase in costs after creating the OBTS app for maintenance, additional workload to our customer support team, and marketing. These costs should be offset by an increase in purchases of SSH Cameras, given their increased functionality with the addition of the OBTS app.

Privacy and security concerns

Creating the OBTS app will involve processing our customers occupancy data to create chore and recreation schedules. As such, we must be careful in ensuring that our customers are well informed of the new way their data is being processed, as well as make sure that we do not introduce new security vulnerabilities when handling their data in TSA. We do not anticipate on using any data not already collected by our exiting SSH Products. In addition, our legal team must ensure the terms and conditions for the OBTS app are set out appropriately and comprehensively cover us on a legal basis.

Risks

Table 3: The Risks

Risk	Mitigation

Students may not feel the chore and recreation schedules are appropriate or accurate.	We will use feedback from users to tweak various aspects of the OBTS app such as the occupancy thresholds. We may implement a more informed way to determine schedules in the future.
The OBTS app may be used by bad actors to stalk individuals or to view personal information.	To combat this, we will make it clear in the app that users can contact us to report others they believe to be suspicious.
Students may not want to have schedules generated for them.	The OBTS app will not generate schedules for students unless they have the app and consent.
Students may not use the OBTS app.	We will advertise the OBTS app by including pamphlets in every SSH Camera box. Also, we shall send an email advertising the new app to anyone who's purchased an SSH Camera.

Supporting material

- Worsley, J.D., Harrison, P. and Corcoran, R., 2021. The role of accommodation environments in student mental health and wellbeing. BMC Public Health, 21, pp.1-15.