A Smart, Energy Efficient Home

Stage 1 Report

F29SO - Group Project

2019 - 2020

Group 3 | Sinderet Green | ***Uplink***

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Preface

‘We’ shall refer exclusively to **Uplink**, the Edinburgh-based Software Development company.

‘The system’ and ‘the product’ shall refer exclusively to the smart home control system, otherwise known as a ‘Building Management System (BMS)’ product offering provided by **Uplink**.

Contents

1 Stage One Roles

We have assigned the following roles for stage 1 based upon availability and experience:

Organisational Manager: Samual Bernett
Technical Manager: Benjamin Milne
Group Reporter: Andrew Sime
Group Liaison: Euan Gordon
Software Developers: Robert Hardiment, Adam Sterling

2 Market Research

2.1 Purpose

The aim of this market research is to gain a perspective on what the current market is offering in terms of smart home hubs. Companies like Google, Amazon, Samsung and Hive have smart home hubs that have very similar features and integrations. The aim is to find a gap in the market for a new device that is original yet desirable and gives the user more features and more control of their smart devices in their home.

2.2 Data Collected

Feature Research

Research was conducted to find features that could be implemented on our device. Research was carried out on current Smart Home Hubs in the market. These smart home hubs included Google Home, Amazon Echo Dot (Amazon Alexa), Hive Hub and Samsung SmartThings.

	Google Home	Amazon Echo Dot	Hive Hub	Samsung SmartThings	Web Application
Turn Of Lights	x	x	x	x	x
Thermostat Control	Needs Hive or Nest	Needs Hive or Nest	x	x	x
Smart Plug Control	x	x	x	x	x
Security Cameras	x	x	x	x	x
Speaker Control	x	x	Needs Google or Alexa	x	x
Locking Doors	x	x	x	x	x
Home Appliance Integrations (Washing Machines etc)	x	x	Needs Google or Alexa	x	x
Smoke Detectors	x	x	Needs Google or Alexa	x	x
Energy Costs					x
Solar Panel Energy Readings					x
Energy Usage Per Device					x
Advanced Room Temperature Control					x

Features of Current Smart Home Hubs

Data collected showed that current smart home hubs have very similar features. Some features are made for their respective devices like turning off the lights or locking doors. Thermostat Control for Google Home and Amazon Echo Dot require integration of a third party system like Hive or Nest to facilitate this feature. Hive Hub requires a substantial amount of integration with other systems to meet the features of the other smart home hubs. These integrated features are third party apps that the system can install, these apps may not appear when the device is first activated by the user. Samsung SmartThings has no integration with any other system and has all their features dedicated to their own system.

Our Additional Features

From this research we would like to go down a similar route to Samsung SmartThings and have all of our features native and dedicated to our system. Our system will have additional features that include room by room temperature readings, solar panel energy readings, energy usage per smart device and projected energy costs.

Room by Room temperature readings is not currently available to the other smart home hubs. The other hubs only feature an average temperature over the whole home. This feature for our device will allow us to recommend the user to turn on the heating in only set parts of the home that require the most heat.

Energy usage per device not currently part of any smart home hub system. This feature will allow the user to see what devices are burning the most energy. From this feature we can create notifications for if the device is being used frequently or if a device has been left on for a substantial amount of time. From the information about the amount of energy being burned from each device we aim to provide details on energy costs for the home.

Some homes now have solar panels to provide clean energy. We will have a feature not provided by any of the above smart home hubs which is to record the use and current capacity of energy being stored by the solar panels. This data can be used to provide insightful information on how efficient the home is at consuming energy.

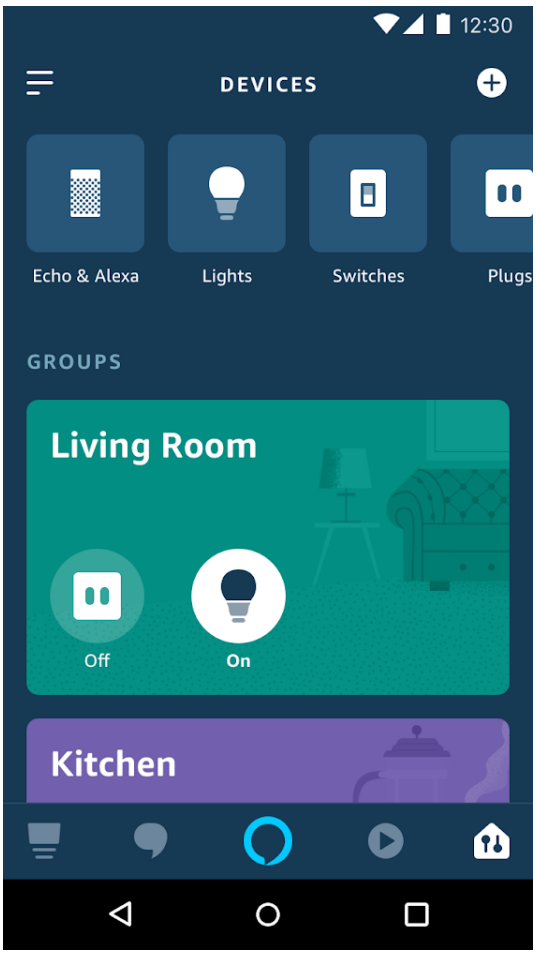
UI Research

Research was conducted to find inspiration on how we will design our UI. Inspiration was taken from Google Home App and the Amazon Alexa App. Market research was done using mobile apps as more people actively use their mobile than a desktop computer. Google and Amazon were chosen for their UI designs as these companies are at the forefront of the market that we intend to get into.

Google Home - Home Page

Very simple and to the point design. Features buttons that lead to set categories of devices and services. Has room by room grouping of devices with playful use of colour and simple icons that creates an attractive design.

Amazon Alexa - Device Page



Simple blocky design that focuses on icons to make the design attractive. Design revolves around creating cards for each room and/or device, making it simple to understand how to use the app.

Our UI Design

Our UI we wish to create will feature similar aspects of both of the above UI designs. We want our UI to be simple and to the point like the Google Home app yet have bold buttons and cards for devices and rooms to make the design attractive for all.

3 Requirements Modelling

3.1 Stakeholders

We have identified the following individuals and groups to consider while designing and marketing our system:

1. Homeowners using our system
2. Children living in a household with our system
3. Guests to a household with our system
4. Building managers with multiple properties using our system
5. Rivals with competing solutions
6. Power companies
7. Maintainers of our system

We have documented the following functional and non-functional requirements, and assigned them priority using the MoSCoW method. This priority is denoted by the letter in the requirement's ID.

3.2 Functional Requirements

Priority Requirements

F-M-1 Friendly and graphical user interface
We want our system to be easy to interact with, regardless of age or technical ability, so having an intuitive and welcoming interface is paramount.

F-M-2 Display and record electrical usage (in/out)
Keeping track of our energy usage is tricky. We want our system to be able to show per-device and overall usage of electricity, as well as what electricity is being produced by renewables.

F-M-3 Display and record heat levels
Our system must be able to inform the user of both indoor and outdoor temperatures around the home. Heating the home is one of the most electrically-intensive tasks, and so our system should let the user make more informed decisions as to when and how they warm the home. If permission is granted, the system itself can use this data to control the home's temperature.

F-M-4 Enable & disable devices
Our system should be able to enable, disable and configure smart devices around the home.

F-M-5 Reminder & warning notifications
The user should be able to configure the system to remind or alert them to data under certain circumstances, such as excessive energy usage, low or high temperatures, etc.

F-M-6 The service should be available 24 / 7
The system will be based in the home. It should have absolute minimum downtime, and the interface should always be available to the user.

F-M-7 Available on multiple devices
Our system's interface should be functional from desktop, tablet and mobile devices.

Additional Requirements

F-S-8 Property manager's view
A property manager should be able to view the data from one of their properties.

F-S-9 User must be able to delete data
Data is important. The user should be able to delete data the system has stored at any time.

F-S-10 Configurable users and permissions
The system should have configurable user levels, such as homeowner, guest, child or property manager.

F-C-11 Calculate energy savings & difference over time
The system could use extra data, such as the cost of electricity for the homeowner, to calculate how much their usage is costing. It could also show the difference in usage and cost over time using historical data.

F-C-12 Historical data control
The system could allow the user to control how long their data is kept for.

F-W-13 Add / configure any number of devices
The system will be compatible with many devices. We would like our system to be compatible with most smart devices, and be infinitely extensible to work with any number of them at once.

3.3 Non-functional Requirements

NF-M-1 Logging service must record data to SQL database
The system will record data as SQL into either a MySQL or SQLite database.

NF-M-2 Devices should communicate over MQTT

NF-M-3 Configuration saved to persistent storage
We need our system to be able to recover from power loss.

NF-M-4 API must retrieve data from SQL database
We will have a separate API which will return our data as JSON.

NF-S-5 MQTT protocol should use WebSockets
The system should use more secure WebSockets for communication.

NF-S-6 Minimal / instant response time for configuring devices
The system should not delay when enabling, disabling or configuring devices around the smart home.

NF-S-7 Hub should be able to report data Upstream
The system should be able to send data Upstream to a property manager's system via an API secured using HTTPS.

3.4 Use Cases

Use Case: AddRoom
ID: 1
Goal: The homeowner adds a room associated with their home
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1.Web Application is running 2. Homeowner must be logged in 3. Homeowner is on Show Device Screen
Postconditions: 1. The room is present in the device database 2. The homeowner can associate devices with the new room
Main flow: 1. Home owner selects Add a New Room through the application 2. Application displays icons to select, and room name to customise 3. Home owner submits room icon and room name 4. Application verifies the room doesn't exist with device database 5. Room added to device database 6. Application provides Add Devices screen
Alternative flows: 4a. 1. Room name is present 2. Home owner is informed the room name is present 3. Return to step 3 main flow

Use Case: DeleteRoom
ID: 2
Goal: The homeowner deletes a room associated with their home
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1. Web Application is running 2. Homeowner must be logged in 3. Homeowner is on View All Devices Screen
Postconditions: 1. The room is removed from device database
Main flow: 1. Applications fetches list of rooms from device database 2. Application provides a list of all rooms 3. Home owner selects edit and room 4. Application displays configuration for the room 5. Home owner selects remove room 6. Application removes selected room from device database 7. Application returns home owner to View All Devices screen

Use Case: BusinessCosts
ID: 3
Goal: The building manager views the business costs
Primary actor: Building manager
Secondary actor(s): Business database, application
Preconditions: 1. Web Application is running 2. Building manager logged in 3. Building Manager selects View All Building Screen
Postconditions: N/A
Main flow: 1. Application fetches list of buildings from device database 2. Application displays list of buildings 3. Building manager selects building 4. Application fetches electrical costs associated with given building 5. Application displays the electrical costs

Use Case: DeleteUser
ID: 4
Goal: The homeowner deletes their data from the user database
Primary actor: Homeowner
Secondary actor(s): User database, application
Preconditions: 1. Web Application is running 2. Homeowner must be logged in 3. Homeowner is on the application settings screen
Postconditions: N/A
Main flow: 1. Application displays settings screen 2. Homeowner selects Delete Smart Device Data 3. Application displays confirmation 4. Homeowner confirms deletion 5. Application removes user data from the user database 6. Application returns homeowner to start screen

Use Case: Login
ID: 5
Goal: A Homeowner logs into the Web Application
Primary actor: Homeowner
Secondary actor(s): Homeowner
Preconditions: 1. Web Application running 2. Homeowner has login permissions 3. Homeowner is on login screen
Postconditions: 1. Web Application validates login details 2. After validation grant Homeowner with access to the web application
Main flow: 1. Homeowner enters login details 2. Web Application validates data 3. Web Application communicates with the user database 4. Web Application grants Homeowner with access to the web application 5. Web Application goes to Homeowners personal web page
Alternative flows: 2a) Homeowner is not registered to the user database 1. Web Application alerts the customer they are not registered 2. Go to Use Case ID 6, Step 1 2b) Homeowner has provided incorrect password but right email 1. Web Application alerts the user they entered the wrong password 2. Go to Main Flow, Step 2 *a) Homeowner decides not to register 1. Web Application closes and does not store any data 2. Main Flow ends *b) Web Application not running 1. Present user with error server down message and to try again later 2. End Main Flow

Use Case: RegisterUser
ID: 6
Goal: A new customer registers with the system
Primary actor: Homeowner
Secondary actor(s): User Database
Preconditions: 1. Web Application is running 2. Homeowner is not registered
Postconditions: 1. Homeowner information is verified and validated 2. Web Application processes the customer data to the user database storing a new customer
Main flow: 1. Homeowner is presented a registration form on website 2. Homeowner fills out form 3. Web Application validates the data is correct 4. Web Application enters user data into the library user management database 5. Homeowner is presented with a successful registration message 6. Homeowner brought to login screen
Alternative flows: 2a) Homeowner is unable to fill out the form 1. Web Application assists user with feedback on potential reasons why the form isn't finished 2. Return to step 2 in Main Flow 3a) Homeowner data is incorrect or not valid 1. Web Application alerts the user the form is incorrect 2. Refresh the form for the user to correct 3. Return to step 2 in Main Flow 4a) Homeowner can not be added to user database 1. Web Application alerts there has been a server error 2. Return to step 2 in Main Flow *a) Homeowner decides not to register 1. Web Application closes and does not store any data 2. Main Flow ends *b) Homeowner Application not running 1. Present user with error server down message and to try again later 2. End Main Flow

Use Case: AddDevices
ID: 7
Goal: User successfully adds a new smart device to the system
Primary actor: Homeowner
Secondary actor(s): MQTT Service
Preconditions: 1. Homeowner is logged in 2. Room is available to add new device 3. Web Application is running and accessible 4. Homeowner is on the add device screen
Postconditions: 1. Web Application sends MQTT message to add new device 2. User shown success message
Main flow: 1. Homeowner goes to add device settings 2. Homeowner selects the room they want to add the device too 3. Homeowner fills out device details 4. Web Application sends message to MQTT service to add device 5. Homeowner presented with success message 6. Homeowner returned to personal home page
Alternative flows: 2a) Room to add device not created 1. Go to Use Case ID 1, Step 1 3a) Device data is incorrect or not valid 1. Web Application alerts the user the form is incorrect 2. Refresh the form for the user to correct 3. Return to step 2 in Main Flow 4a) Web Application can't send a message to MQTT Service 1. Web Application alerts there has been a server error 2. Return to step 3 in Main Flow *a) Web Application not running 1. Present user with error server down message and to try again later 2. End Main Flow

Use Case: RemoveDevices
ID: 8
Goal: A Homeowner wants to remove a device from a room
Primary actor: Homeowner
Secondary actor(s): Device Database
Preconditions: 1. Homeowner is logged in 2. Room is available with device they want to remove 3. Web Application is running and accessible 4. Homeowner is on the Room screen
Postconditions: 1. Web Application sends “delete” to device database to remove it from the Home Owner’s device list 2. Homeowner shown success message
Main flow: 1. Homeowner goes to remove device settings 2. Homeowner selects the room they want to remove the device from 3. Homeowner is presented with confirmation message 4. Web Application sends “delete” to device database to be removed 5. Homeowner presented with success message 6. Homeowner returned to personal home page
Alternative flows: 1a) Device is not listed 1. End Main Flow 3a) Homeowner cancels device deletion at confirmation message 1. Alerts Homeowner the device was not deleted 2. Return Homeowner to main home page 3. End Main Flow 4a) Web Application can’t send “delete” to device database 1. Web Application alerts there has been a server error 2. Return to step 2 in Main Flow *a) Web Application not running 1. Present homeowner with error server down message and to try again later 2. End Main Flow

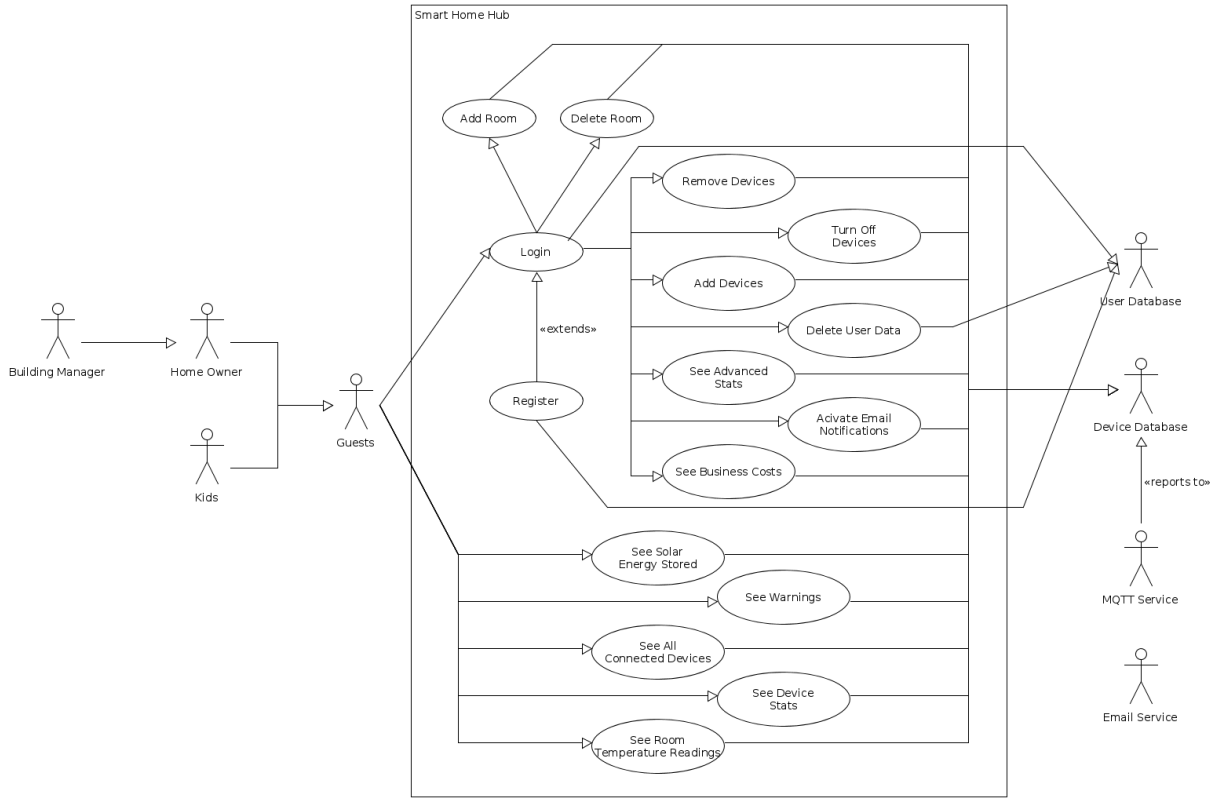
Use Case: SeeSolarEnergy
ID: 9
Goal: To display the amount of solar energy stored in the house
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1. The web application is running 2. The homeowner must be logged in 3. The homeowner must be on the home screen
Postconditions: N/A
Main flow: 1. The homeowner selects the ”solar stored” selection from the home page 2. The application will get the amount of solar energy stored from the device database. 3. The application will then display the amount of energy stored

Use Case: SeeWarnings
ID: 10
Goal: To display all the warnings that a house has generated
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1. The web application is running 2. The homeowner must be logged in
Postconditions: Database notified that user has seen warning
Main flow: 1. The homeowner selects the “warnings” selection from the home page. 2. The application get the list of warnings from the database 3. The application displays them by rooms and severity.
Alternate flow: 1. The application shows a popup showing the warning when the user logs in. 1. The homeowner logs in 2. A popup appears with the warnings. 3. Homeowner clicks the popup and is continued from step 2

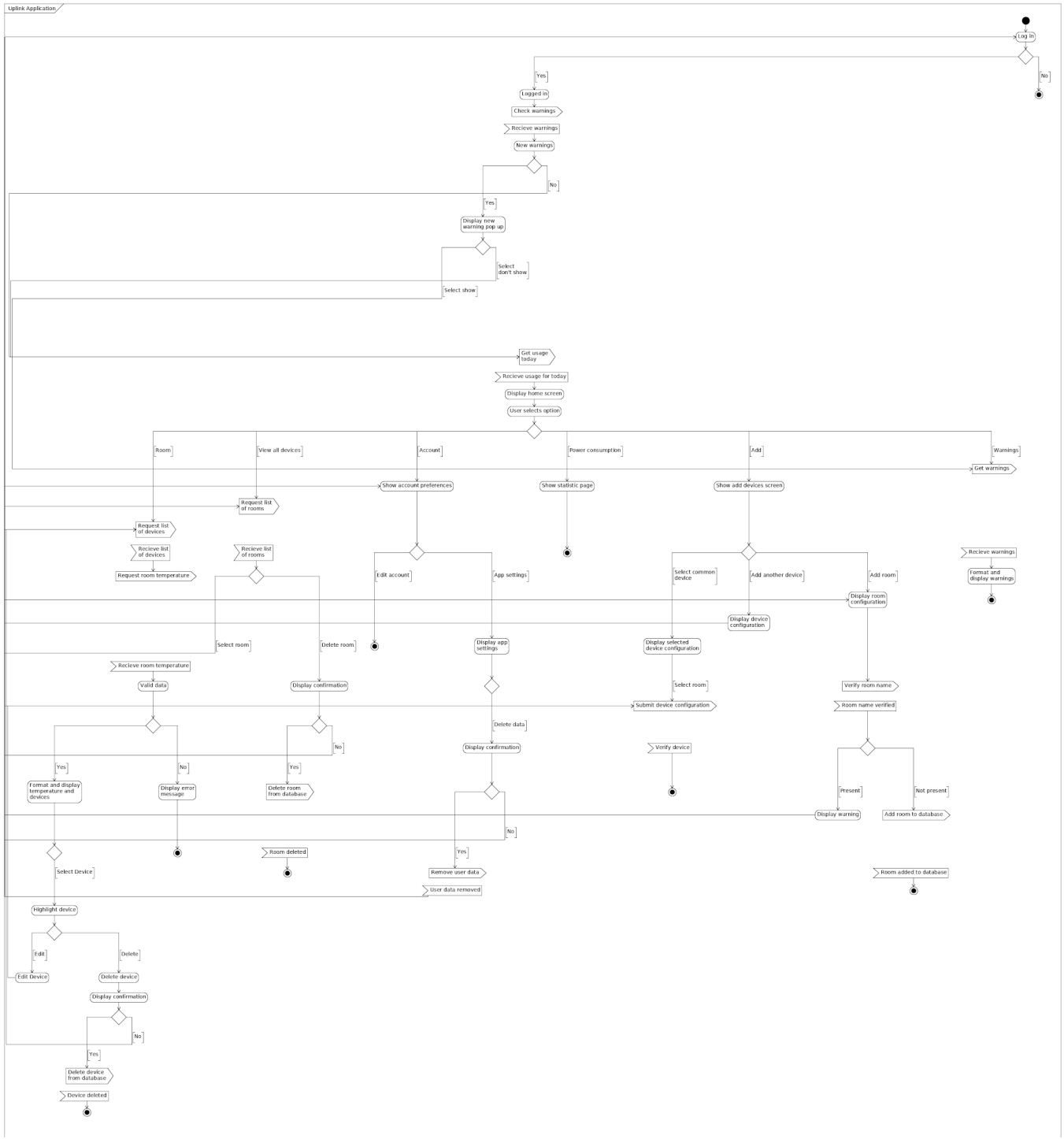
Use Case: SeeConnectedDevices
ID: 11
Goal: To display all the connected devices
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1. The web application is running 2. The homeowner must be logged in 3. Homeowner is on the main screen
Postconditions: N/A
Main flow: 1. Homeowner selects the “view all devices” option from the home screen 2. The application gets a list of all connected devices in the house 3. The application displays the list of connected devices.

Use Case: SeeRoomTemp
ID: 12
Goal: To display the temperature readings
Primary actor: Homeowner
Secondary actor(s): Device database, application
Preconditions: 1. The web application is running 2. Homeowner must be logged in 3. Homeowner must be on the main screen
Postconditions: N/A
Main flow: 1. The homeowner clicks on the room they wish to view from the main screen. 2. The application will contact the device database and request the temperatures of the selected room 3. The application will then display the status page for the room with the temperature at the bottom.

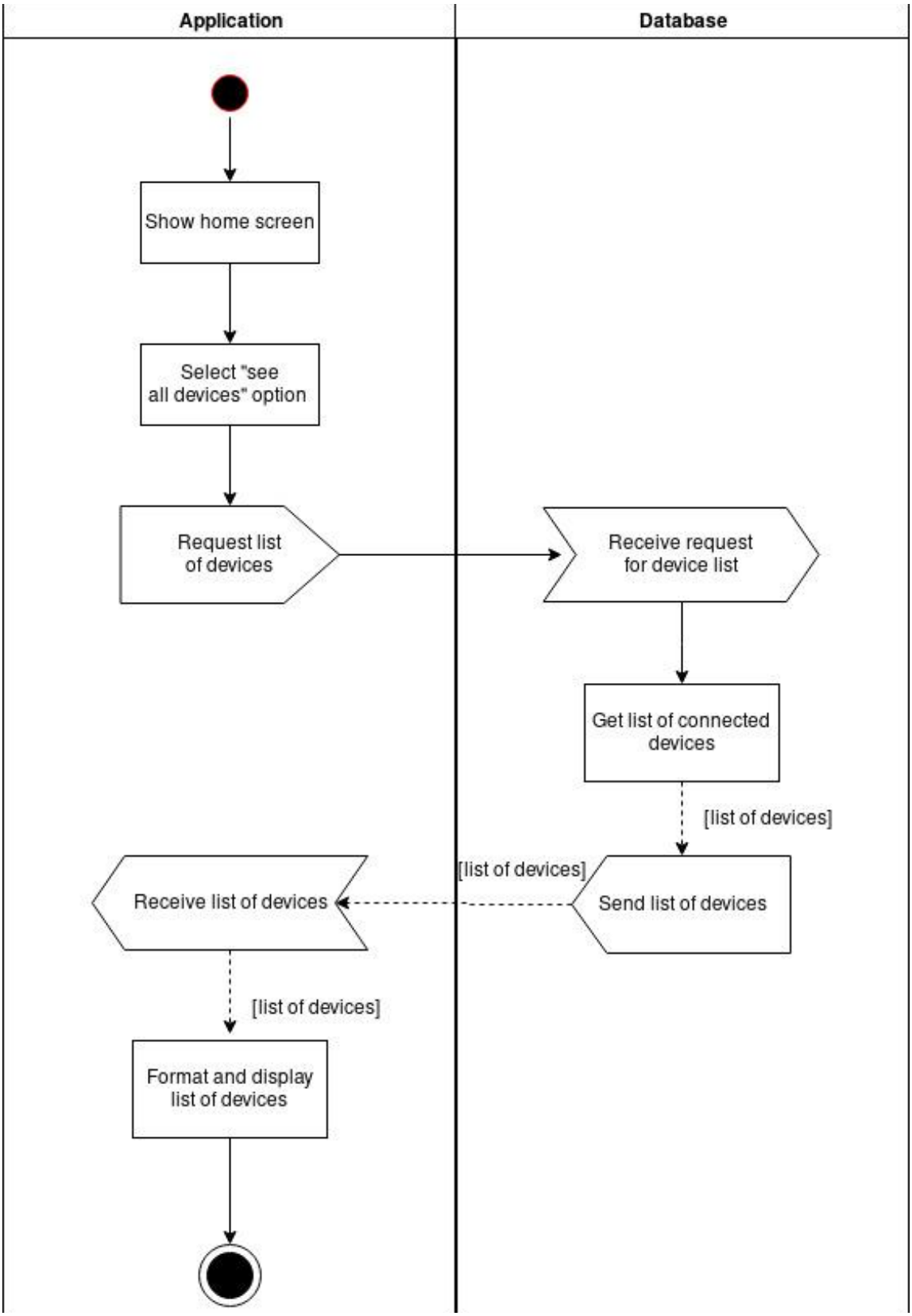
Appendix



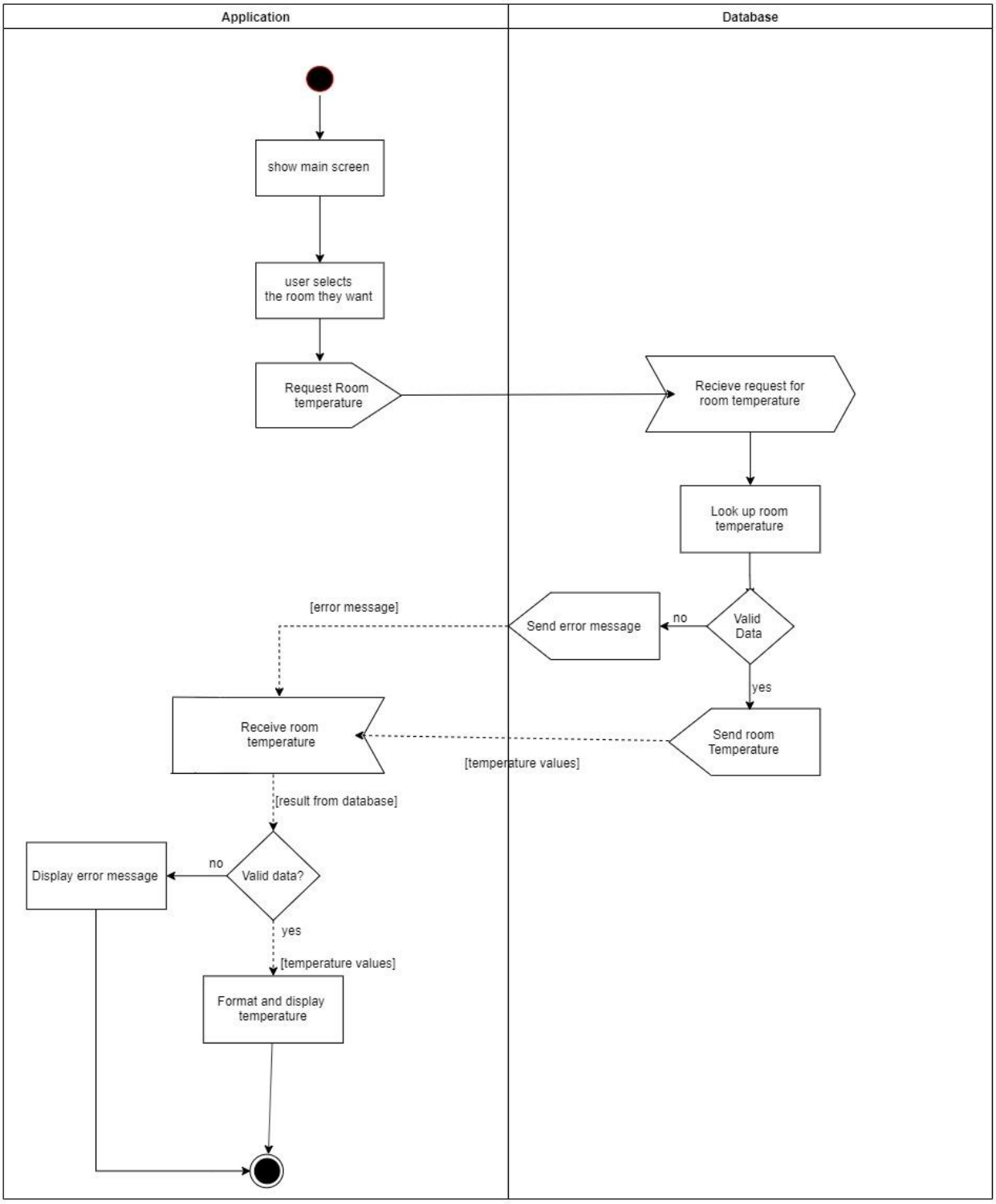
Overview of the Uplink Hub's interactions between users and services



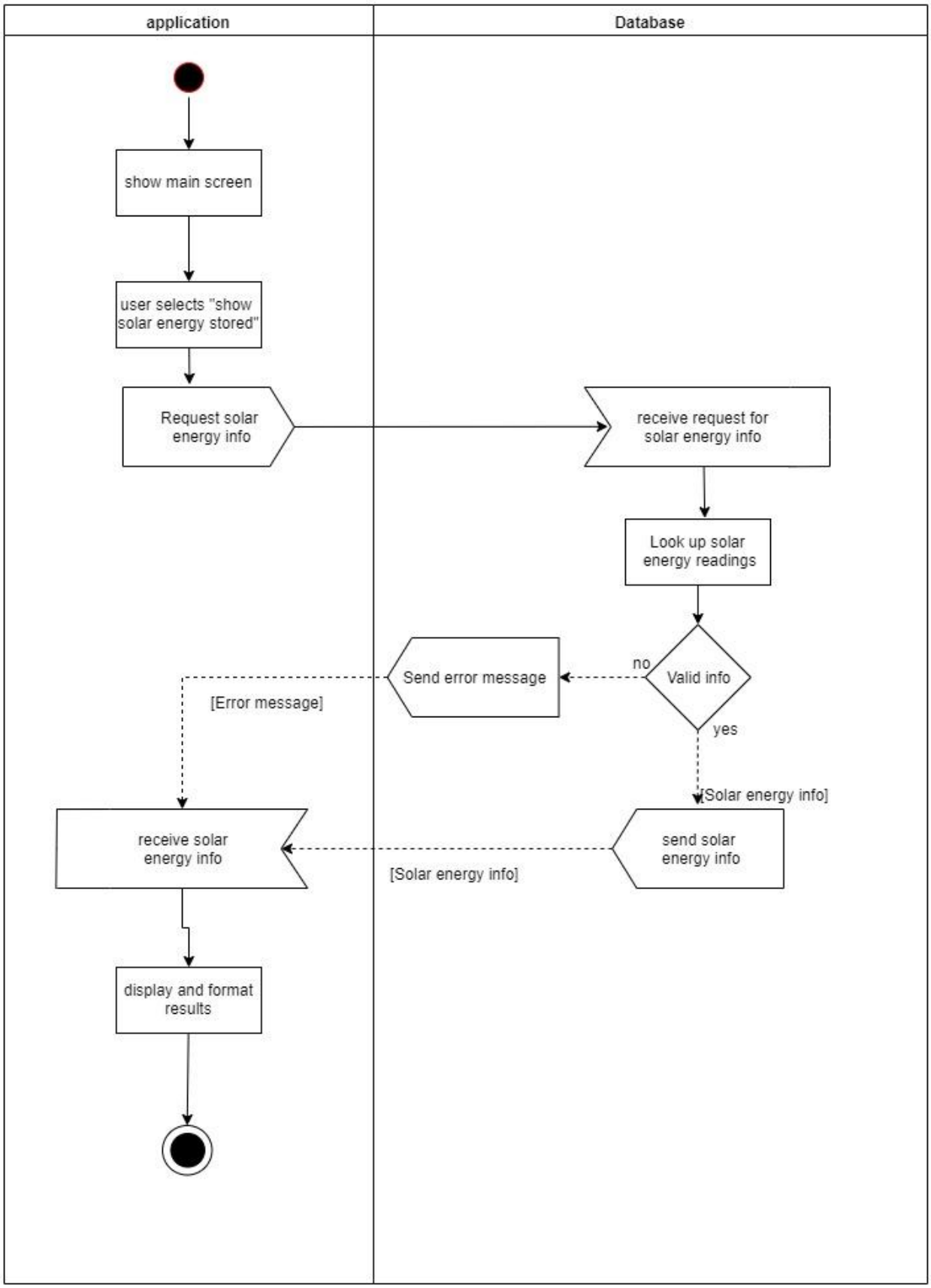
Overall Activity Diagram for the Web Application



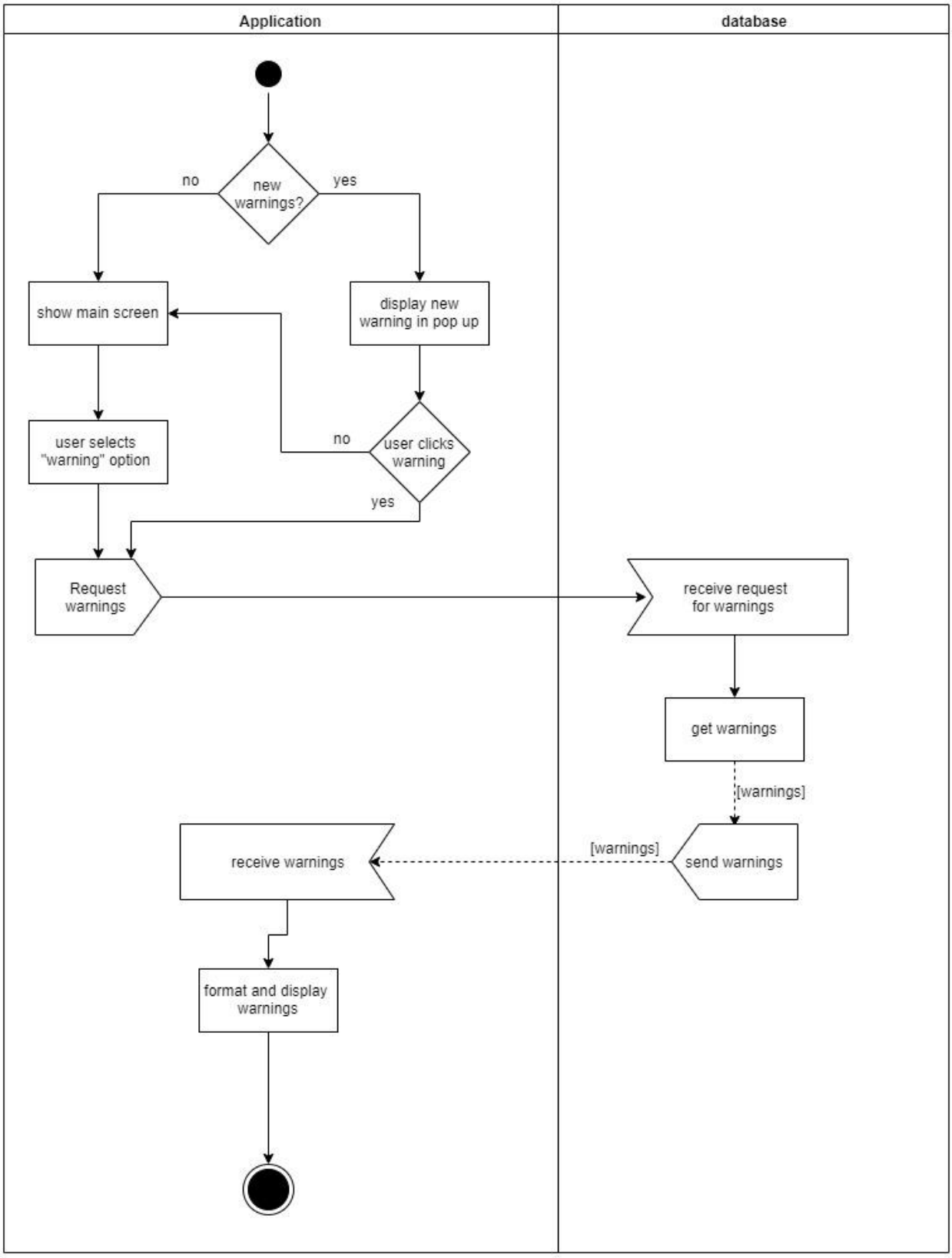
View all Device Activity Diagram



Display Room Temperature Activity Diagram



Display Solar Energy Info Activity Diagram



Display Warnings Activity Diagram

4 Risk Analysis

Below is a table of the risks to ourselves / the project that we have identified. Impact is marked between 1 and 10. Probability is marked between 0.1 and 1. Concern is calculated using:

Concern = Impact * Probability

The strategy we take in response to the risk is determined by the following:

Concern > 15 : Eliminate
Concern => 10 : Mitigate
Concern < 10 : Recognise

Risk	Type	Cat.	Imp. /10	Prob. /10	Concern /100	Strategy
Exams / Coursework	Est.	Project	6	6	36	Ensure constant review of Gantt planner and ensure team is meeting deadlines
Adverse Weather	People	Project	4	5	20	Ensure all members have access to all project data at all times, so as the loss of a member never entails a loss of work
Requirement Change	Req.	Product	6	3	18	Ensure the team is consistently reviewing Requirements and checking in with client
Missed Deadline	Est.	Product	5	3	15	**SEE:** Exam / Coursework
Resource Performance Issues	Tools	Product	6	2	12	Ensure multiple team members can run project tools on their platforms
Death	People	Project	10	1	10	**SEE:** Adverse Weather
Group Discourse	People	Project	5	2	10	Regular meetings and public discussions of all project on-goings
Plagiarism	People	Project	10	1	10	I mean, just don't
Illness	People	Project	3	3	9	**SEE:** Adverse Weather
Data Loss	Tech.	Project	8	1	8	Ensure all project data is saved to Google Drive / GitHub Cloud storage, and not on any single member's device
Requirements Incomplete	Req.	Product	4	2	8	**SEE:** Requirement Change
Client Rejects System	Req.	Business	7	1	7	**SEE:** Requirement Change
Group Change	People	Project	4	1	4	**SEE:** Adverse Weather
Market Forces (e.g. Brexit)	Org.	Business	2	1	2	N/A

5 Project plan

5.1 Product Overview

Our product will be targeted towards two groups:

1. Owners of eco-efficient smart homes
2. Property managers overseeing a portfolio of smart homes

Our product will be designed to link up with a vast range of smart devices, expanding the smart eco-system to every corner of the home - and beyond. Our system will be able to give smart suggestions and make decisions to aid the owners or property managers in reducing their carbon footprint and living a healthier, more economical life.

For the homeowners

We will partner with home builders to provide our system as standard when purchasing a new, eco-efficient home. The system will be based around an ‘uplink-hub’ which will communicate with the ecosystem, record smart data and provide the homeowner with an interface to view and configure their smart home.

We will also provide these smart devices and our uplink-hub aftermarket for homeowners looking to introduce our smart ecosystem to their home.

The system will provide the homeowner with a one-stop-shop to control devices and view reports from around their smart home. It will allow them to enable and disable devices, set triggers, alarms, timers, and view a plethora of reports on data such as temperature, humidity and energy.

The smart home will allow the homeowner to divide their devices and reports into rooms, making it easier to get the data they need, when they need it. It will also allow the triggering of groups of devices.

For the property managers

Property managers employing our system will be able to fetch data from multiple uplink-hubs and view the same data as the homeowners themselves through one central view. They will be able to configure varying levels of control the homeowner has over the system, and set similar triggers and alarms as the homeowner might through their own panel and the homeowners’.

5.2 Technical Overview

Devices

Our smart devices themselves will be programmed using **C** or **Python**. Although not in the scope of this project, we have elected these two languages as they work well on the embedded microcontrollers which power our devices and have good library support for IoT protocols.

Connectivity

In order to communicate between devices we will use the MQTT protocol. Designed for lightweight messaging between low-powered devices, it is well-supported in most languages. It requires a Broker to receive and relay messages between devices, which is one of the services our uplink-hub will provide.

We considered using the BACnet protocol, however it would require establishing our own networking solutions, whereas MQTT will ride on the home's wireless connection. We also have experience using MQTT.

Back-end

The homeowner's back-end will be split into multiple services, each running locally on the uplink-hub:

1. **Broker:** We will use the Mosquitto MQTT Broker as it has ARM builds for smaller devices such as the Raspberry Pi and supports secure WebSockets.

2. **API:** Our local API service will subscribe to and record all data streams to an SQLite database. We've chosen this DBMS as it does not require a separate server and can be easily backed up. It will be written in Node.js using Express.js, specifically designed for a responsive API. This service will also send data upstream to a property manager's hub if configured to do so.

   The API will respond with data in JSON format.

   The API will be publicly documented and hobbyists will be encouraged to build their own systems around it.

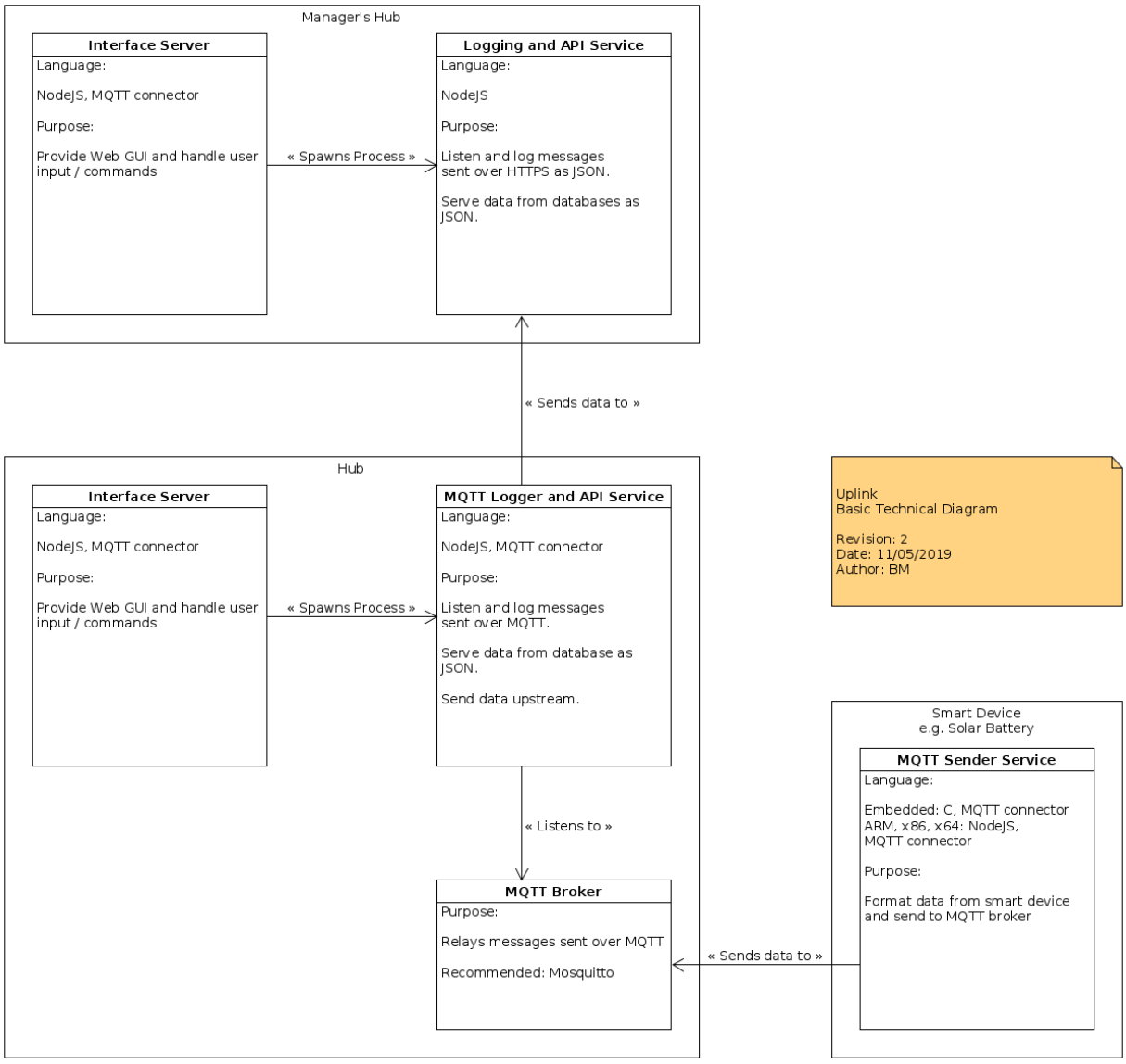
3. **UI Server:** Our interface will be provided by a Node.js webserver and serve pages which make calls to our API. Users and permissions to view, edit and interact with devices will be stored in an SQLite database.

The property manager's system will be similarly structured, except it will not involve an MQTT Broker and the API will be available for uplink-hubs to periodically dump their data to, or pull updates from.

Front-end

We have elected to create the majority of our front-end using Vue.js, which provides a built-in ability to automatically update pieces of the user interface as variables change. This allows us to fetch data from an API and easily display it on our interface. Our homeowner and property manager UI designs will be constructed similarly, but with different options.

Systems Overview Diagram



5.3 Databases

Uplink will not, themselves, retain any user data. We provide a self-contained product for homeowners and property managers wherein they control all related data. **Uplink** takes no responsibility for data shared beyond these parties.

The data stored in the uplink-hub will be as follows, per-table:

User Permissions & Accounts
- Username
- Password
- Account level
- Time & date created
- Last active

Layout data
- Room name

Sensor data
- Sensor type
- Time & date connected
- Room
- Last active

Sensor reading data
- Time recorded
- Value

Recurring timer data
- Device
- Time(s)
- Day(s)
- Time created
- Action

Timer data
- Device
- Time end
- Time created
- Action

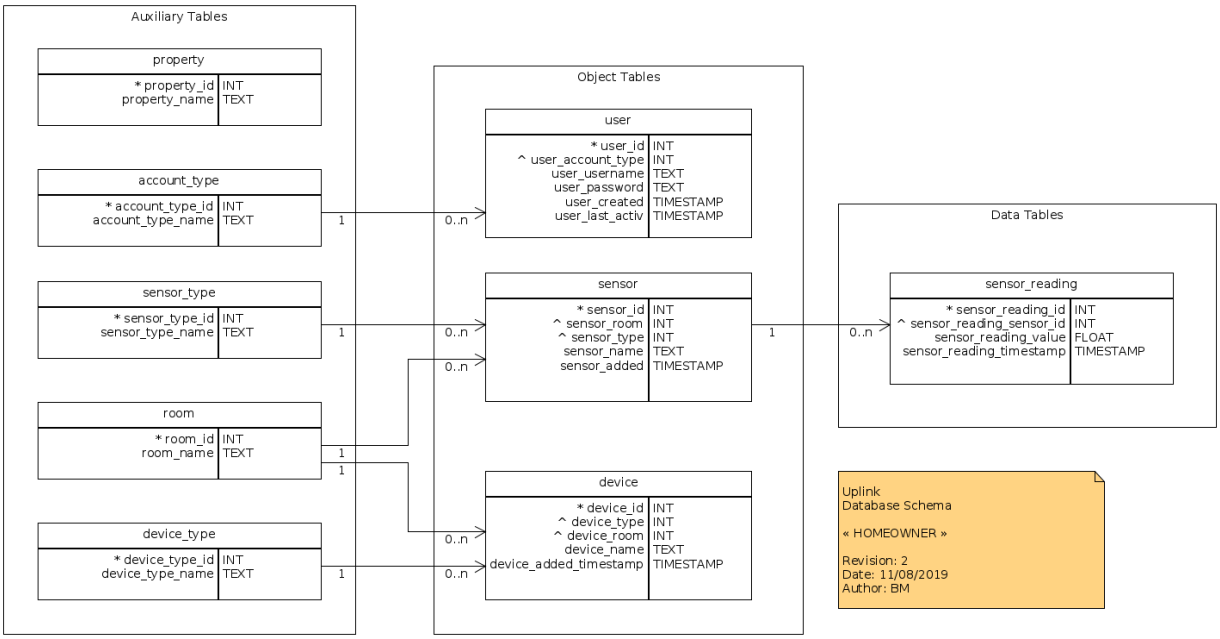
Trigger data
- Device
- Trigger
- Action

The data stored in a property manager's system will be the same on a per-house basis. There will be a separate database for each property. Their system will also have the following additional tables:

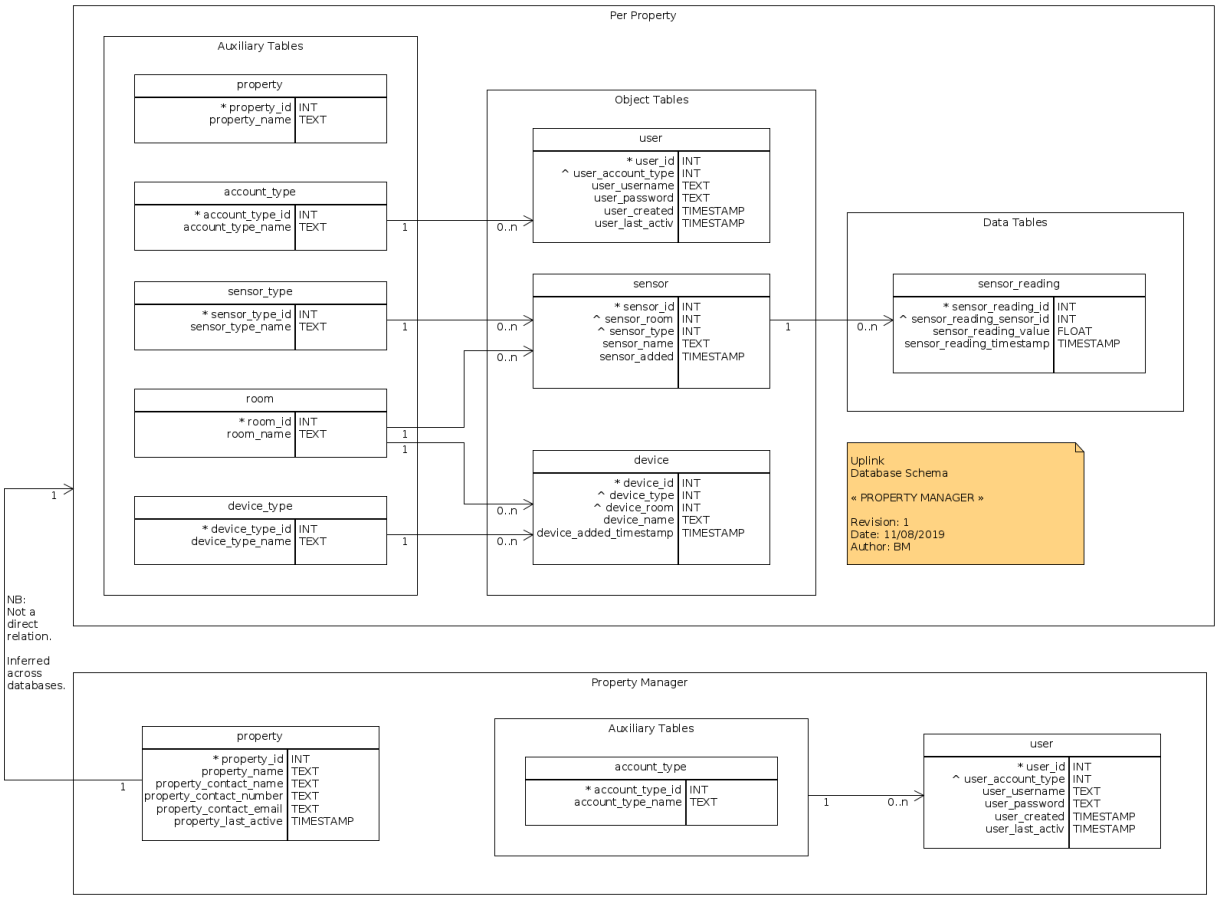
User Permissions & Accounts
- Username
- Password
- Account level
- Time & date created
- Last active

Property data
- Location
- Last active
- Contact person
- Contact telephone

Database Schema - HOMEOWNER



Database Schema - PROPERTY MANAGER



5.4 Development Plan

Communication and Management

Our team communicates primarily over a WhatsApp group chat and tracks tasks via Trello, which enables us to assign tasks to members, designate priority and generate a Gantt chart using a powerup by TeamGantt.

For file management we have a Google Drive folder which we use for non-technical files and a GitHub repository for our project code.

Prototyping

The system will be prototyped on a test server hosted on hutchie.scot. The services are described below:

URL	Internal Port	Service
uplink-homeowner.hutchie.scot	5551	Homeowner's front-end
uplink-manager.hutchie.scot	5550	Property manager's front-end
uplink-ho-api.hutchie.scot	5552	Homeowner's API
uplink-m-api.hutchie.scot	5553	Property manager's API

Sprints

Our development process will be split up into sprints, as described in the following table:

▼ **Stage 2**	**0%**		**Start**	**Due**	**Assigned**
▼ **Sprint 1**	**0%**				
Solidify Database Design	0%		Nov 28, 2019	Dec 5, 2019	Adam Sterling, Andy Sime, Benjamin Milne, E...
Build Databases in SQLite	0%		Nov 28, 2019	Dec 5, 2019	Adam Sterling, Andy Sime, Benjamin Milne
Prototype web frameworks for promotional website	0%		Nov 28, 2019	Dec 5, 2019	Robert Hardiment, Sam Barnett
▼ **Sprint 2**	**0%**				
Create service for mock MQTT I/O	0%		Dec 5, 2019	Dec 12, 2019	Benjamin Milne, Euan Gordon
Build sensor API	0%		Dec 5, 2019	Dec 12, 2019	Adam Sterling, Andy Sime, Benjamin Milne, E...
API Testing	0%		Dec 5, 2019	Dec 12, 2019	Robert Hardiment, Sam Barnett
▼ **Sprint 3**	**0%**				
Standardise UI design	0%		Dec 12, 2019	Dec 16, 2019	Euan Gordon
Build login and basic website skeleton	0%		Dec 12, 2019	Dec 19, 2019	Adam Sterling, Andy Sime, Benjamin Milne, E...
Login security testing	0%		Dec 12, 2019	Dec 19, 2019	Adam Sterling, Andy Sime, Benjamin Milne, E...
Prototype promotional website	0%		Dec 12, 2019	Dec 26, 2019	Robert Hardiment, Sam Barnett
▼ **Sprint 4**	**0%**				
Build user settings menus	0%		Dec 19, 2019	Dec 26, 2019	Benjamin Milne, Euan Gordon
▼ **Sprint 5**	**0%**				
Build API key generator	0%		Dec 26, 2019	Jan 2, 2020	Adam Sterling, Andy Sime, Benjamin Milne, E...
Test comms using API key	0%		Dec 26, 2019	Jan 2, 2020	Adam Sterling, Andy Sime, Benjamin Milne, E...
Build webpage for API gen	0%		Dec 30, 2019	Jan 2, 2020	Adam Sterling, Andy Sime, Benjamin Milne, E...
Plan database for storing timers, etc.	0%		Dec 26, 2019	Jan 2, 2020	Adam Sterling, Andy Sime, Robert Hardiment,...
▼ **Sprint 6**	**0%**				
Write functions for averaging temperature, etc. using API	0%		Jan 2, 2020	Jan 9, 2020	Adam Sterling, Andy Sime, Robert Hardiment
Test chart UI	0%		Jan 2, 2020	Jan 9, 2020	Euan Gordon
Build database for storing timers, etc.	0%		Jan 2, 2020	Jan 9, 2020	Adam Sterling, Andy Sime, Benjamin Milne
▼ **Sprint 7**	**0%**				
Write async functions for toggling devices using API	0%		Jan 9, 2020	Jan 16, 2020	Adam Sterling, Andy Sime, Benjamin Milne, E...
▼ **Sprint 8**	**0%**				
Integrate chart views with data from API	0%		Jan 16, 2020	Jan 23, 2020	Benjamin Milne, Euan Gordon
Build per-device settings menus	0%		Jan 16, 2020	Jan 23, 2020	Adam Sterling, Andy Sime, Benjamin Milne, E...

6 Project costings

6.1 Resource Breakdown

Direct Costs

People
- 1 X Project manager
- 1 X Lead software developer
- 2 X Software developers
- 1 X Designer
- 1 X Database manager

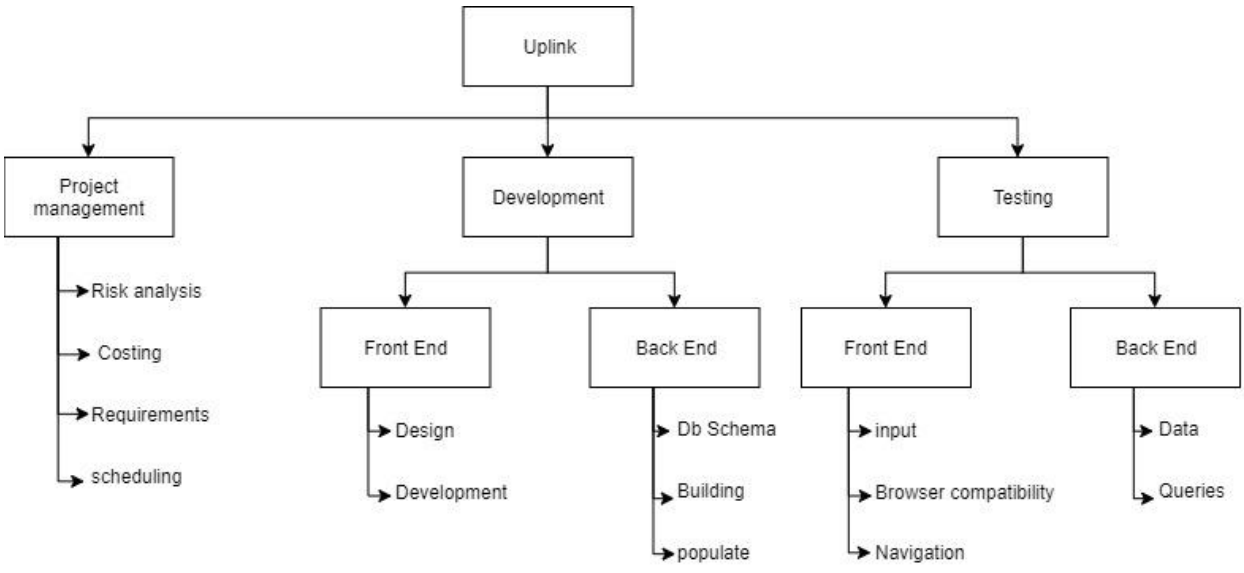
Hosting
- Web hosting
- Database Hosting

Indirect Costs

Overheads
- Office rent
- Electricity
- Heating

Equipment and machinery
- Computers
- Software Licenses

6.2 Work breakdown structure



6.3 Analysis

Direct Costs

1. People
   Each person will put in roughly 150 hours each over the 9 month period.

    a. Project manager
       The salary of the Project manager, responsible for the management and oversight of the project. Actions contingency plans. Deals with updates to client.

    b. Lead Software developer
       In charge of the development of the software. Same function as Software Developers but with extra roles

    c. Software Developers
       Development of the software.

    d. Designer
       Design the front end of the system. (UI & UX)

    e. Database system Manager
       Manage and design the Database used for the system.

2. Hosting

    a. Web Hosting
       External web space to host the system.

    b. Database Hosting
       External location for the database.

Indirect Costs

1. Overheads
    a. Office rent

    b. Electricity
    to run the office equipment and keep the lights on

    c. Heating
    Cause no one likes coding in a cold room

2. Equipment and machinery

    a. Computers
    To use for the development and management of the system

    b. Software licenses
    If Windows will be Included with the computer. Linux is free.

    c. Testing Devices
    To be able to test the system on various screen sizes and platforms.

6.4 Figures

Direct Costs

These are the costs are clearly specific to the project

People

Resource	Cost per hour(£)	Quantity	Total(£)
Project manager	34	150	5100
Lead software dev.	32	150	4800
Software dev.	15	300	4500
Database manager	17	150	2550
UI designer	26	150	3900
		Total	**20850**

Hosting

Hosting	Provider	Cost per month(£)	Total(£)*
Dedicated Web hosting	HostGator	92	828
Database hosting	AWS	54.20	380
		Total	**1208**

*Potentially the hosting does not need to be up for the full 9 months as the first few months will be used for design and rudimentary testing before being put up fully for testing. However, it will be budgeted as the full 9 months of hosting.

Direct Costs Total: £22,058

Indirect Costs

These costs are not directly related to the development of the project but are still incurred and should be budgeted for

Overheads

Resource	Cost per month(£)	Total(£)
Office space	2700	24,300
Electricity	170	1,530
Heating	71.3	642
	Total	**26,472**

Equipment

Equipment	Cost(£)	Quantity	Total(£)
Development PCs	500	5	2,500
Licenses*	0	0	0
Testing Devices**	0	0	0
		Total	**2,500**

*Licenses will be provided with the PCs and open source software used, therefore no costs.
**the staff can use their devices(laptop tablets, phones etc) to test the system, therefore no cost is incurred.

Indirect Costs Total: £28972

Costs Total **£51030**

6.5 Contingencies

It is prudent to allocate extra funds to the budget to pay for any uncertainties. (A. Haniff, 2016).

Taking into consideration the fact that this is a fairly low risk project the contingency budget should be around 5%, however with the nature of the staff being skilled, highly trained individuals we shall increase the contingency budget up to 10%. This is due to around half of the budget being made up of the staffing costs.This will ensure that if any staff take any time off, due to illness or the sort, there is enough money to allow for replacement staff members to be found.

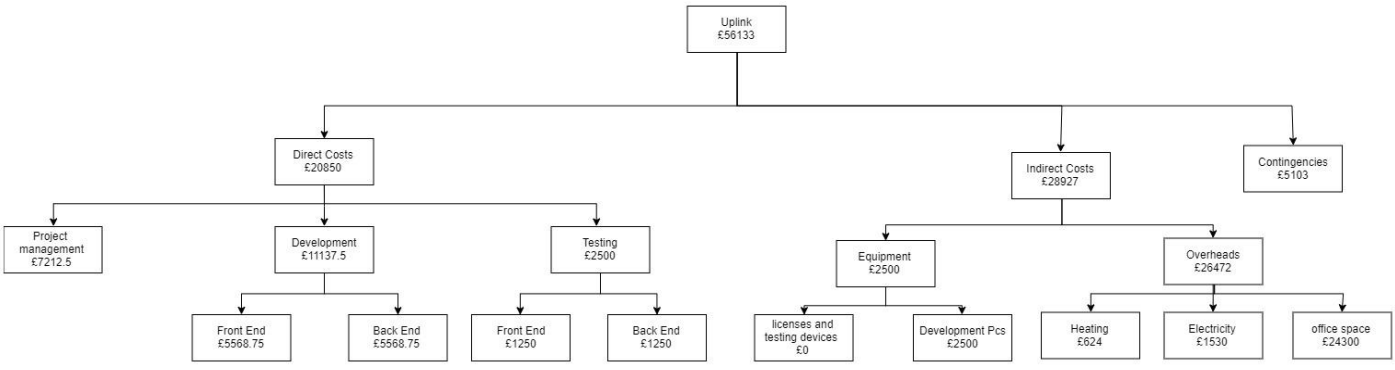
Also having the website and database being handled offsite means that we are not in control if the services they provide go down. Having some extra money means we could switch to another service while the other service fixes their issues.

As stated in our risk analysis, the risk of having requirements change is of relatively high probability and impact. Requirements changes could be costly and would require overtime from staff or the hiring of a contractor or new staff member and so would cost more money to manage. This is another reason why increasing the contingency budget is a good idea.

6.6 Total

Cost:	£51030
Contingency of 10%:	£5103
Total	**£56133**

6.7 Cost Breakdown structure



7 Usability Evaluation

7.1 Purpose

This document is designed to show the usability testing plan outline. This plan focuses on the mock-ups created during the planning stage of development and aims to highlight any issues with the designs and to help improve on them. An Adobe XD file has been used to simulate the use of a UI with the mock-ups created.

7.2 Overview

This document will be split into the following parts

- Test Plan
- Test Protocol
- Findings
- Conclusions
- Appendix

The test plan focuses on how we perform the testing, including the methods that we will use and how they shall be used during the protocol.

The test protocol will show the layout for the tests itself and will be designed to collect a mixture of quantitative and qualitative data which then can be used to formulate further actions.

The findings will be the data we recorded from our participants, and possible improvements that could be made.

Conclusions will include the final decisions made from our findings, including a list of changes agreed upon by the team and how that works alongside any gathered data.

Appendices contain different forms that were used during this usability test. This includes a consent form and a questionnaire to be completed at the end of the test by the participant. The appendix also contains the UI mockups used in our usability test.

7.3 Objective

The test performed will use the various mock-ups that have been created during the planning of the project. Using the different concepts that have been created a series of questions have been derived. The concepts are to be compared as well as individually shown, with the participant giving feedback.

The focus will be on ensuring that each of the planned screens are clear and understandable, with the participant able to highlight what they would do on each screen.

The use of Adobe XD will be used to let a user attempt the navigation of the mock-ups to help ensure that the navigation of the application will be understandable.
The tests should highlight any improvements that need to be made to help improve the final design of the system.

7.4 Test Plan

The aims of the tests are as follows:

- Collect qualitative and quantitative data from the participants of the test about the planned function and design of various mock-ups. These could be as follows:
    - Navigational issues
    - Design issues
- To gather user feedback and improve upon current designs

The application is designed to be used by homeowners, as well as residents of the home. The tests will be performed on members of the public and will take place in various locations, depending on the participant. All tests will have at least one member of the group present for supervision. Various uncontrolled external factors will be apparent due to the change in venue; however, this will give the ability to test on various computing devices.

The goals of the test have been extracted from the created requirements during this stage of the project. However due to this being a visual prototype without any functionality the main requirement that is being tested is, F-M-1, Friendly and graphical user interface.

7.5 Methodology

The usability tests will focus on a small group, who will be individually recruited from various walks of life. Each test will be conducted individually with the use of Adobe XD to simulate a working user interface as well as stills of various designs. Questions will be asked to gather various information as well as allowing the participant some time to attempt to navigate the UI.

7.6 Participants

Jakob Nielsen, Principle of the Nielsen Norman Group states that the ideal number of testers is 5, as more starts to produce diminishing returns. Due to this, a group of between 5 and 7 participants will be gathered.

The participants recruited will be of various age groups and backgrounds to help give a broad view on the system and to assess its ease of use. The participants will be selected from acquaintances of the team, with a focus on trying to have a diverse pool.

7.7 Training

Outside of the explanation on how adobe XD works, there will be no training on how the planned system will work. The participants will be informed on what the system is meant to do and its functionality to ensure that they have an idea of what to expect. This will give a clearer vision on how new users will experience such a design, giving the ability to log any repeated issues.

7.8 Procedure

Participants will be taken to a convenient location with a member of the project team. The supervising team member will get the participant to sign a consent form and inform them about the test and that the focus of the test is the Adobe XD file they will be shown and to speak as they go through the tests.

The participant will then be given access to the Adobe XD file on the first screen and be given a series of tasks to complete as the supervisor observes. There will be no recording of the session to safeguard the participants identity.

The supervisor will take note of any questions the participant has, as well as any issue they encounter. The participant will be told that they can ask any questions they require to complete the tests but encouraged to try and complete it by themselves. Due to this being a mock-up using Adobe XD the only recordable errors will be with the test file and therefore not recorded for future evaluation.

7.9 Test Goals

This section describes the usability goals for the program.

7.10 Completion rate

The completion rate of the task is the percentage of participants who complete the tasks without any critical errors. Critical errors are errors that disrupt the task resulting in a failed outcome.

This test theoretically should not have any critical errors due to it being a series of designs being examined, however this still will be considered in case a situation arises. The ideal completion rate is 100%.

7.11 Error free rate

The error free rate is the percentage of tasks completed without any errors. This includes both critical and noncritical errors. Noncritical errors don't cause the task to fail, however they would impact the ability to complete tasks efficiently.

7.12 Problem Severity

To ensure that recommendations created after the completion of this study are properly acted upon, the severity of problems will be recorded. These will be ordered using two factors. The impact of the problem and the frequency of the problem. The classifications for these issues were found on Usability.gov template.

7.13 Impact

This is the ranking of the issues caused by the problem. These three classifications have been found on the template provided by usability.gov:

- High - prevents the user from completing the task (critical error)
- Moderate - causes user difficulty but the task can be completed (non-critical error)
- Low - minor problems that do not significantly affect the task completion (non-critical error)

7.14 Frequency

The frequency is how often the problems occur. Using the classifications found on the usability.gov template is as followed:

- High: 30% or more of the participants experience the problem
- Moderate: 11% - 29% of participants experience the problem
- Low: 10% or fewer of the participants experience the problem

7.15 Severity

To organise the severity of the issues the following classifications were used.

- Severity 1 - High impact problems that often prevent a user from correctly completing a task. They occur in varying frequency and are a characteristic of calls to the Help Desk. Reward for resolution is typically exhibited in fewer Help Desk calls and reduced redevelopment costs.
- Severity 2 - Moderate to high frequency problems with moderate to low impact are typical of erroneous actions that the participant recognizes needs to be undone. Reward for resolution is typically exhibited in reduced time on task and decreased training costs.
- Severity 3 - Either moderate problems with low frequency or low problems with moderate frequency; these are minor annoyance problems faced by a number of participants. Reward for resolution is typically exhibited in reduced time on task and increased data integrity.
- Severity 4 - Low impact problems faced by few participants; there is low risk to not resolving these problems. Reward for resolution is typically exhibited in increased user satisfaction.

7.16 Testing protocol

Tester:

Date: Time:

Location:

Participant No.:

Aim

The aim of this session is to gather information on how users navigate the app and how they find each of the pages. This app is designed to allow users to monitor their electric use and to help ensure a cleaner living.

Introduction

The app is designed to allow you to add, monitor and delete rooms and devices to help you track your electrical use. Each room will contain different devices, allowing you to monitor the electricity used.

For this test, I will ask you to look at different screens and complete a few tasks. During this, notes will be taken to log your feedback but any information that identifies you will not be taken to ensure that this test is completely anonymous.

Once you complete the test, we will ask you to complete a short questionnaire to gain some general feedback on what you experienced. During the test, can you make any observations out loud for our records and feel free to ask any questions.

If at any time you wish to stop the test just say.

1. Concept 1 Login Screen
    a. Can you describe the screen?
    b. If I asked you to login how would you do it?
2. Home Usage Screen
    a. Can you describe the screen?
    b. Can you navigate to see the devices in the living room.
3. Room devices tasks.
    a. Can you describe the screen?
    b. Can you show me how you (think you) would delete living room lights 1?
    c. Can you show me how you (think you) would add a new device (Philips Hue lights)?
    d. Can you return to home usage screen?

4. Various home usage tasks

    a. There is an alert. Can you show how you would check the alert?

    b. How would you see advanced settings?

    c. Can you show me how you (think you) would increase font size?

    d. Can you show me how you (think you) would logout?

OK, that is the end of the test. I will now give you our questionnaire to complete to help us gather some more of your feedback on the app.

Thank you for your time.

7.17 Findings

Participant Data

A summary of the numerical results is shown below.

Age:

18-21:	4
21-30:	2
31-40:	0
41-50:	0
51-60:	1
61+:	0

Gender:

MALE:	3
FEMALE:	4

Computer experience:

1	2	3	4	5	6	7	8	9	10
0	0	1	1	0	1	0	1	1	2

Do you own a smart device?

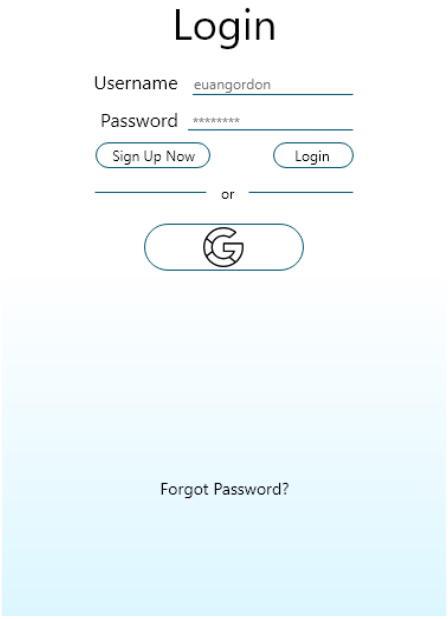
YES:	6
NO:	1

Do you own any of these hubs?

GOOGLE HOME:	1
AMAZON ECHO:	2
HIVE HUB:	0
SAMSUNG SMARTTHINGS:	1

Protocol Findings

Question 1: ***Can you describe the screen?***



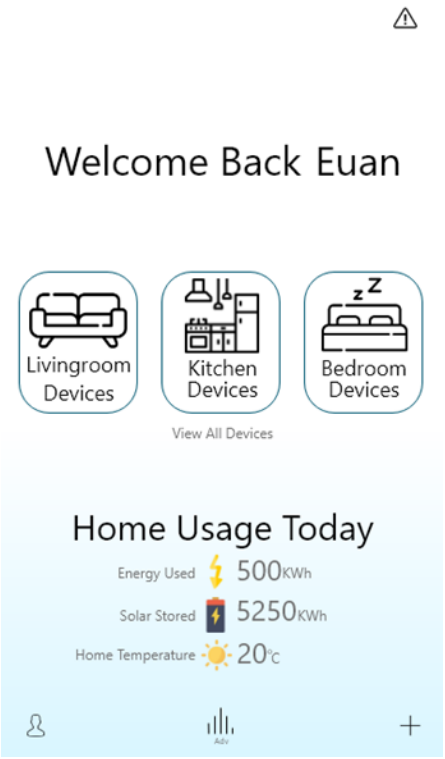
The overall feedback of this page was that it felt professional and modern with a clear minimalistic design.

If I asked you to login how would you do it?

There we no issues with the login process.

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Question 2: ***Can you describe the screen?***



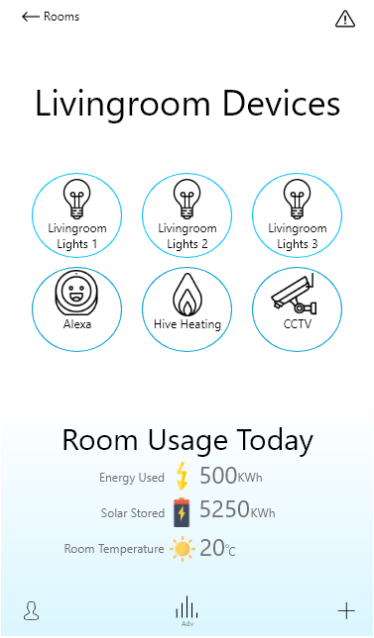
For the homepage there was a few suggestions. Overall the page was said to be clear and easy to navigate. However, suggestions to increase the font of the view all devices and to move the welcome message higher to allow more devices to be shown were given.

Another suggestion was to change or remove the word “devices” from the room list due to the word being repeated excessively.

Can you navigate to see the devices in the living room?

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Question 3: ***Can you describe the screen?***



The feedback to this page was similar to the previous one, however compliments were paid to a better layout by some of the participants.

Can you show me how you (think you) would delete living room lights 1?

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Can you show me how you (think you) would add a new device (Philips Hue lights)?

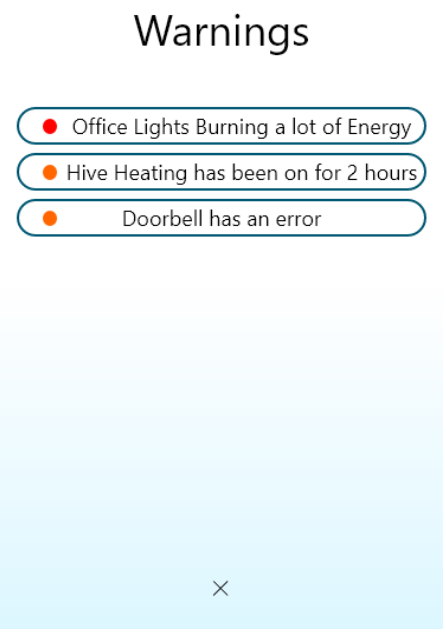
Completed	6
Completed with issues	1
Failed	0
Completion	100%
Error Free	86%

There was a slight confusion over the plus symbol however that did not impact the test, another confusion over the suggested devices being the current devices.

Can you return to home usage screen?

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

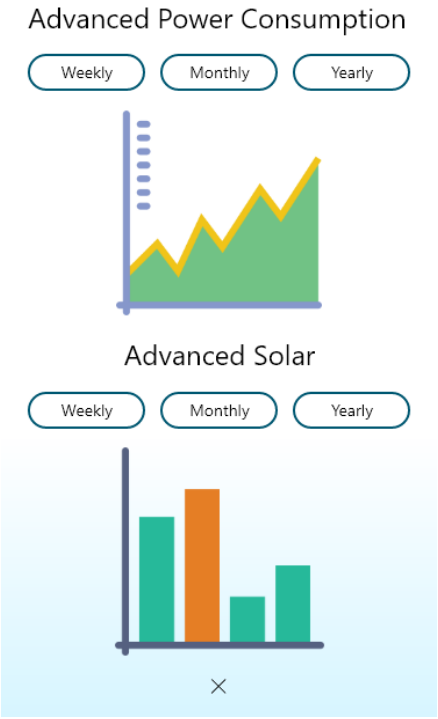
Question 4: ***There is an alert. Can you show how you would check the alert?***



Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

A suggestion for a bigger alert icon and better breakdown of how the alerts are listed (showing room as well) were given.

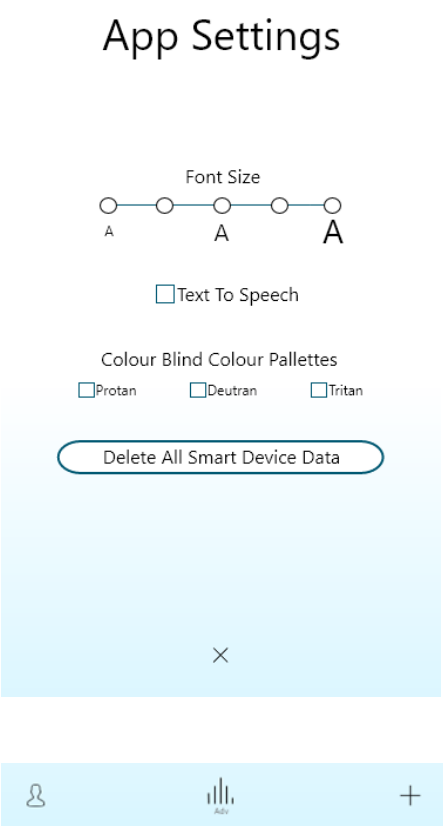
How would you see advanced setting?



Some feedback was given; hoping that there would be more advanced settings in future.

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Can you show me how you (think you) would increase font size?



Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Feedback given on how some participants would like the account and settings sections split up and to use a cog icon instead of the account icon to find settings.

Can you show me how you (think you) would logout?

Completed	7
Completed with issues	0
Failed	0
Completion	100%
Error Free	100%

Post-test Data

State your level of agreement:

		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
A	The design was clear and easy to understand	4	3	0	0	0
B	The design was user friendly	5	1	0	1	0
C	I understood how to navigate the app	2	5	0	0	0
D	The layout was logical	5	2	0	0	0
E	It was difficult to navigate	0	0	0	4	3
F	I did not like the design	0	1	1	1	4

UI Design

Overall the feedback on the design was positive, with participants saying they liked the simple and clean UI. However, many said that they would like to see more colour in the future design as one said the screens could be “a lot more engaging”.

Some feedback gathered from the tests, suggested that the rooms page could use some tweaking to remove some of the white space at the top and allow more space for functionality.

Navigation

The navigation tests showed that the applications current navigation setup, while clear could use some adjustment. Larger icons, with some colour to help highlight what they are, were suggestions that were given.

Another common suggestion was to split the profile and the settings into two separate icons.

7.18 Conclusions

The usability testing highlighted some issues with our UI. With the information gathered we will be able to make improvements for the future live version. Our test completion goals were very high, with only a single minor error in one of the tests. Alongside this, we have gathered feedback about changes to help improve the application for users.

We consider this a step in the right direction for the completion of the requirement F-M-1, A friendly and graphical user interface. This will be used as a future baseline in tests during production of the application. All our test participants are interested in future tests, which will allow us to compare these responses to help improve our design.

Agreed Changes

General

- Add a bit more colour to help engage user
- Increase icon size
- Add Colour to Icons
- Split settings and account into different tabs
- Increase clarity of icon use

Rooms page

- Remove the word devices from room titles (e.g. Livingroom devices to Livingroom)
- Raise Welcome back message to allow another row of rooms
- Increase font size of view all devices

Add new Devices

- Make suggested devices clearer that they are common devices

Warning Page

- Make icon a bit bigger for warnings
- Better breakdown of warnings (e.g. highlighting room first)

Advanced settings

- More options for display

7.19 Appendix

Bibliography

Nielsen, J. (2000). Why You Only Need to Test with 5 Users. [online] Nielsen Norman Group. Available at: https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/ [Accessed 3 Nov. 2019].

Usability.gov. (2013). Usability Test Plan Template | Usability.gov. [online] Word Document. Available at: https://www.usability.gov/how-to-and-tools/resources/templates/usability-test-plan-template.html [Accessed 2 Nov. 2019].

Consent Form

Uplink

Heriot-Watt University

Consent to act as a participant in Usability Study

Principal Investigators: Robert Hardiment, Benjamin Milne, Samuel Barnett, Adam Sterling, Andrew Sime, Euan Gordon

Description: The goal of this study is to gather feedback on our current UI design.

There are minimal risks for participants of this study. Any personal information collected during this study will be kept secure on a password protected computer. This study will not affect the participants' relationship with Heriot-Watt University or impact any ongoing courses.

This study is optional and participation can be refused. If you take part in this study, you can withdraw at any time. This will not affect your relationship with Heriot-Watt University in anyway.

Voluntary Consent

I certify that I have read the proceedings and that I understand its contents. Any questions I have asked have been answered by a member of the study team. My signature below means I agree freely to take place in this study, and I consent to the use of these results for scientific purposes and any recordings or transcriptions to be used for research purposes so long as my identity is not revealed. I understand I have the right to refuse any questions asked to me.

_____ _____

Date Subject Signature

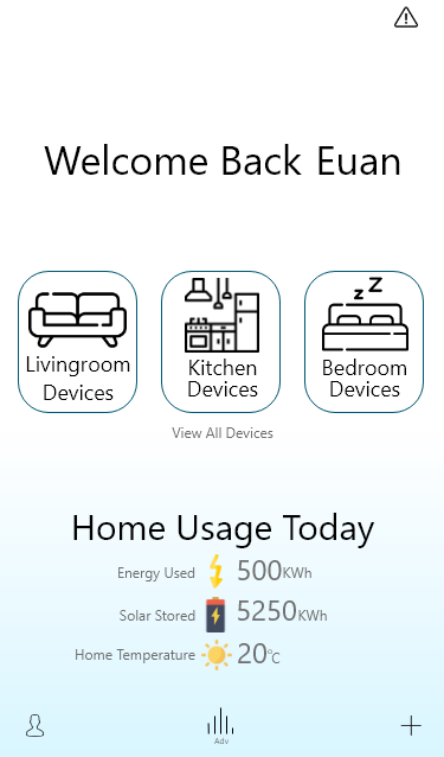
Investigator's certification

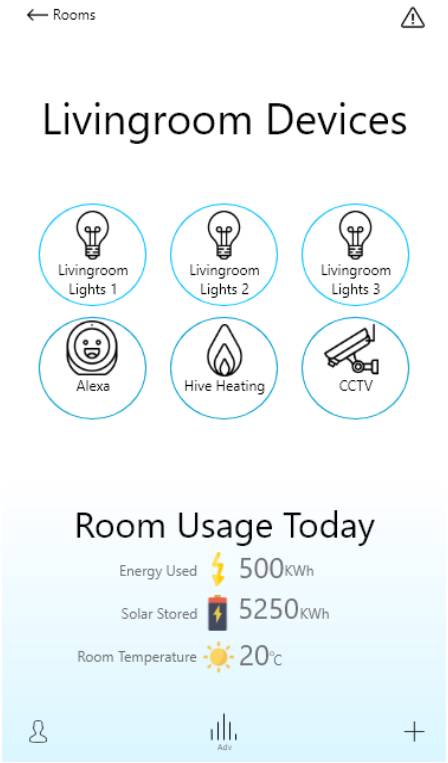
I certify that I have explained the studies true nature and purpose as well as any risks involved. The potential benefits of the study have been explained and I have asked any questions that have been raised and I have witnessed the participant signing.

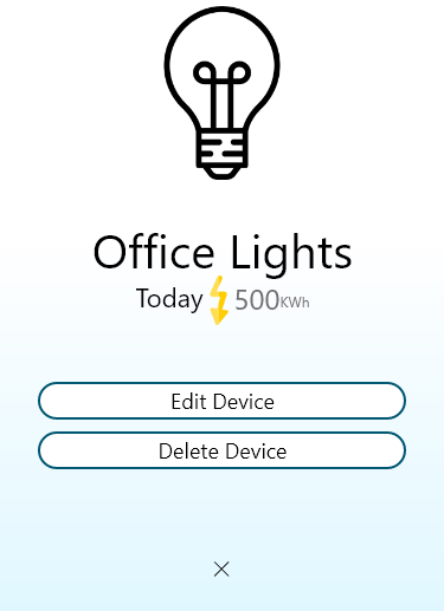
_____ _____

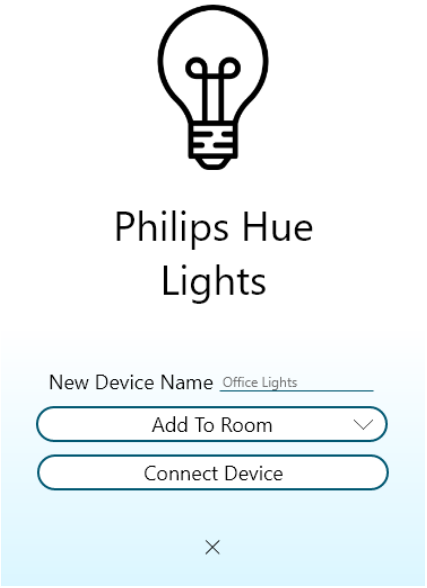
Date Investigator Signature

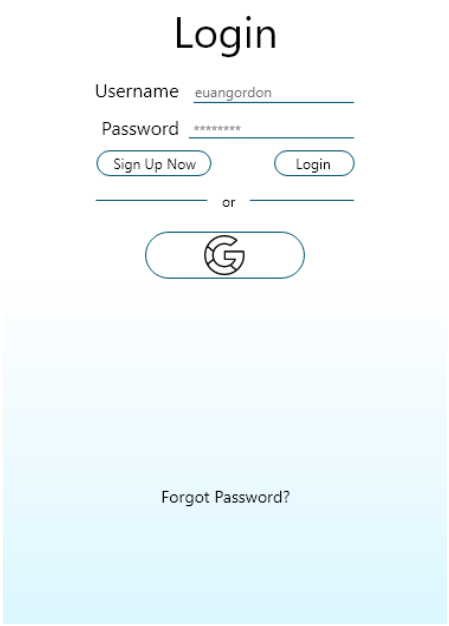
Mockup Design

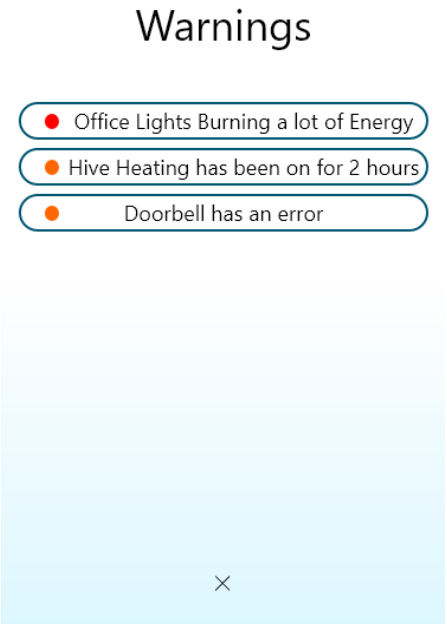


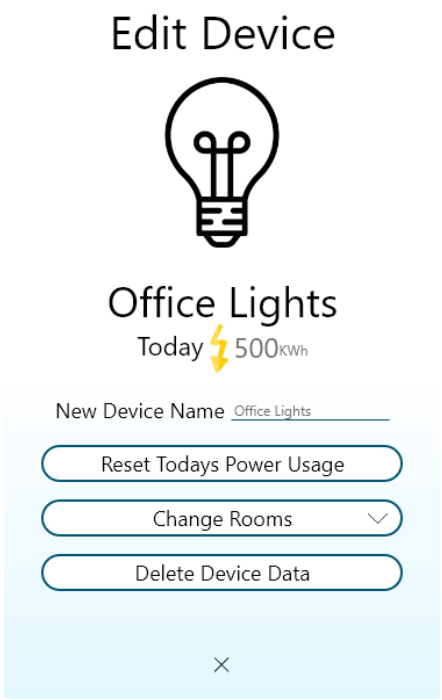


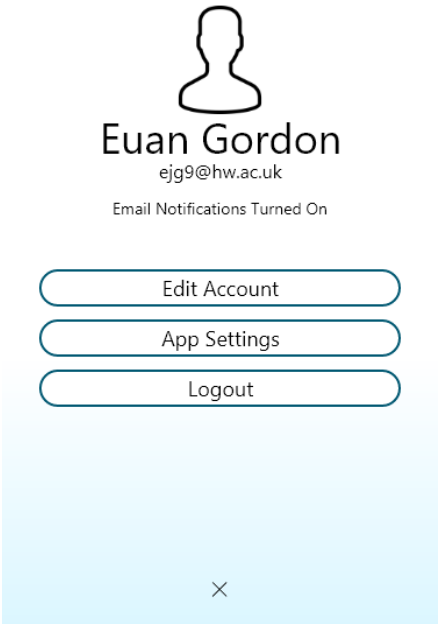





Login
Username
euangordon
Password
Sign Up Now
Login
or
Forgot Password?


Warnings
Office Lights Burning a lot of Energy
Hive Heating has been on for 2 hours
Doorbell has an error


Edit Device
Office Lights
Today
500KWh
New Device Name
Office Lights
Reset Todays Power Usage
Change Rooms
Delete Device Data


Euan Gordon
ejg9@hw.ac.uk
Email Notifications Turned On
Edit Account
App Settings
Logout

Add Devices

Add Another Device

Create a New Room

Add a New Room

×

Create a New Room

Add Room Icon

Room Name kitchen

Add Room

×

App Settings

Font Size

A A A

Text To Speech

Colour Blind Colour Pallettes

Protan Deutran Tritan

Delete All Smart Device Data

×

Advanced Power Consumption

Weekly Monthly Yearly

Advanced Solar

Weekly Monthly Yearly

×

Connecting Device

Deleting Device

Demographic Questionnaire

Please Mark X Where applies

1. Age

18-21	
21-30	
31-40	
41-50	
51-60	
61+	

2. Gender: _____

3. Computer Experience

<- Least Experience Most Experience ->

1	2	3	4	5	6	7	8	9	10

4. Do You Own Any Smart Devices?

Yes	
No	

4.1 Do You Own Any of These Smart Home Hubs?

Google Home	
Amazon Echo	
Hive Hub	
Samsung SmartThings	
Other	_____

5. What Feature did you **like** most about the designs shown?

6. What Feature did you most **dislike** most about the designs shown?

7. Please state your level of agreement

		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
A	The design was clear and easy to understand					
B	The design was user friendly					
C	I understood how to navigate the app					
D	The layout was logical					
E	It was difficult to navigate					
F	I did not like the design					

7. Do you have any additional comments?

9. Are you willing to take part in a further study at a later date?

Yes	
No	