



A Smart, Energy Efficient Home

Stage 3 Final Report

F29SO - Group Project
2019 - 2020

Group 3 | Sinderet Green | ***Uplink*** | [Website](#)

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1 Introduction

1.1 Purpose

The purpose of the Stage 3 Final Report ('the Report') is as follows:

1. outline the marketing analysis and strategy undertaken by the Uplink team,
2. provide a high level overview of the software application,
3. provide a detailed expansion of each software component,
4. explain the development methodology used throughout the development process,
5. explain the testing undertaken throughout the development process,
6. provide a brief installation and user guide of the software application.

The Report will also include a Project Evaluation, which will detail:

1. how Uplink functioned as an organisation,
2. how effective Uplink were at implementing the software application from planning in Stage 1 through to the end of Stage 3,
3. how complete the software application is at the end of Stage 3 when compared to initial requirements, etc.

The Report is a **confidential document** intended to be viewed only by those listed below:

The Customer	Team Esteem
The Project Manager	Dr. Rob Stewart
The Developers	Sinderet Green ('Team Uplink')

1.2 Scope

The Uplink software application ('the System') is a smart-home control system (also known has a 'Building Management System' or 'BMS') capable of interacting with a multitude of smart devices, record readings from devices & sensors and use recorded data to advise the Customer on eco-efficient energy practices.

1.3 Glossary

MQTT	Message Queue Telemetry Transport for inter-device communication
Mosquitto	MQTT relay
JavaScript	Primarily web-based programming language
Node.js	JavaScript-based back-end language
Vue.js	JavaScript-based front-end library
SQLite	Lightweight database controller
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
Raspberry Pi	Low-power single-board computer
Uplink HUB	The device where the Uplink software will be based
Linux	Operating System alternative to Windows / OS X
JSON	JavaScript Object Notation for standardised data transfers
IDE	Integrated Development Environment
VCS	Version Control System
API	Application Programming Interface
U-HUB	Uplink HUB

1.4 References

- Uplink (2019). Stage 1 Report
- Uplink (2020). Stage 2 Progress Report

2 Marketing Analysis and Strategy

2.1 Summary

Sinderet Green was tasked to build the Uplink system, which is an evolutionary step in the development of the smart house concept. With the development intended to help Team ESTEEM, we believe that The Uplink hub has the ability to help millions of people across the country to save money on their energy and heating bills and give more control and autonomy over their own home.

The smart home market is small but has room for growth. With 2 main players there is not a lot of competition. The market is fractured too. If there was one product to bring them all under one roof, we are confident it would be a massive success, and could create the competitive advantage we need to succeed in this market.

The Sinderet Green marketing plan focuses on developing a small loyal customer base at first with high satisfaction and recommendation levels. This allows for rapid growth as we will allow customers to share their stories and experiences through our social media channels to create more awareness. Using targeted ads means we can create an audience that is receptive to our advertising and willing to try our product. Awareness is the key to growth as customers being aware of us means we will be one of the first that they will research.

The pricing model focuses on hardware sales with the main bulk of revenue coming from the sales of the Uplink Hub. Ancillary products will also be sold to help bolster the revenue numbers. A sales promotion will be employed at certain times to drive sales and boost awareness.

2.2 Goals

The goals of a marketing campaign should create a broad description of what is to be worked towards. These are often aligned with the goals of the business. Marketing affects how well the business goals can be reached. They help to pave the way to success for the company.

- 1. Provide a product to consumers that helps them reduce their energy usage**

The main goal of the Uplink system is to help consumers reduce the amount of energy they consume and in turn reduce the amount they spend on heating and energy in their home.

- 2. Become one of the most well known smart home brands**

Becoming a large household brand will mean that our brand is more likely to come to mind in peoples heads, potential customers will be more open to use our products as we are a reputable company, and we can become one of the big players in the growing smart home device market.

2.3 Objectives

The marketing objectives are a more specific version of the marketing goals, and allow for a measurable defined goal that once reached can be considered to be completed.

Objectives should be **SMART**. This stands for:

Specific - Focused clearly on one defined metric

Measurable - Must have a way to measure it

Aspirational - Must push the company beyond where they are now

Relevant - Must be able to be reasonably achieved

Time-bound - Must have a date to end upon or a defined time scale to achieve it.

All Goals must meet the criteria of being SMART. This allows for the best possible chance to achieve them as they are as defined and possible. The path to complete them should be relatively obvious.

1. Generate revenue of over £1,000,000 within the first year
 - a. Gain 5000 paying customers
 - b. Have a Marketing Qualified lead(MQL) rate of 40%+
 - c. Have a Sales Qualified Lead (SQL) rate of 40%+
 - d. Get 15000+ website views
 - e. Get 300,000+ social media advert click throughs
2. Become one of the most well known smart home device companies.
 - a. Within 3 years of release, uplink will be one of the options in 30% of customers' consideration set.
 - b. 50% of customers would recommend the Uplink hub

Being in a customer's consideration set means that when a potential customer thinks of smart house devices we are one of the options that springs to their mind. The benefit of this is that there is very little resistance to a customer researching us if we are in their consideration set. For high involvement products such as smart home devices being in the consideration set is important as customers will invest a lot of time researching and deciding on the product they want to buy.

Word of mouth is a powerful tool for marketing as people will buy things or not on the recommendation of their friends or family. If customers are satisfied with their products they will recommend it. If the recommendation rate is high we will have a set of customers essentially being brand ambassadors that will spread awareness of our product for us.

2.3.1 Key Performance indicators (KPI)

Key performance indicators allow you to measure how effective a marketing campaign is. These are used to evaluate the progress of goals set out above. These key performance indicators should be reviewed as often as once every week to make sure we are on track to achieve our goals.

Units sold

- How many units are sold

Revenue

- The amount of money brought in from sales and ancillary products

Cost per lead

- How much per new customer brought through inbound marketing
- The smaller the better

Marketing ROI

- The return in terms of money or units sold per how much was spent on advertising

Social media traffic

- How many conversions are we making off of our social media pages and ads.

Customer satisfaction

- How many customers are satisfied with their products

Consideration set rate

- The percentage of people whose consideration set includes the Uplink hub.

2.4 Stakeholders

These stakeholders are people or groups with an interest in the success of the Uplink hub. Stakeholders should be considered when creating a marketing plan and internal stakeholders should be communicated with about the project regarding any changes to requirements or deadlines.

2.4.1 Internal

- Sinderet Green employees
 - These are people who work for sinderet green and they rely on the company for their livelihood. The success of the company means they get to keep their job and income.
- The client
 - The client has ordered the product and would like to see the order fulfilled.
- Heriot watt
 - The success of the project allows for the university to show it as an example of the quality of its students.

2.4.2 External

- Home owners
 - These are the main target demographic of the uplink system and so it is important to create a product that fulfills their needs.
- Competitors
 - Competitors will look to the other companies in the market to see what could possibly be missed opportunities or ideas for them to implement in their own devices.
- Power companies
 - These companies will be looking to see either any company in the market that may help to reduce their profits, by reducing energy usage or they may be looking to buy smaller companies to be used as their proprietary smart home solution.
- Governments
 - Governments will be on the lookout to see what companies are helping with the environmental crisis. They will be interested to see smaller companies that they could provide funding for or government contracts.

2.5 Market analysis

The smart house market seems to be fractured. There isn't one market, there are several smaller markets in it. Such as smart speakers, security, heating, then devices and lighting. Several systems do not do all of them, they specialise, such as sonos specialising in smart speakers.

The market has a lot of room for growth as only 23% of the UK population are smart home devices. The largest portion of people who own smart home devices own smart speakers. There are still a large portion of people who do not own any smart home devices and do not know the benefits of owning one. People who already own a smart home device (that aren't smart thermometers) are open to buying a smart thermometer. Once people have bought into a smart home product they are willing to try more. While only a minority of people are open to it buying more smart devices there are plenty of people who do not own any smart home devices and would be willing to try them out if shown the benefits.

2.5.1 General overview of the market

Currently smart speakers are the most popular smart home device with 11% of the population owning one. Smart speakers are speakers that have a virtual assistant built in. Such as Google Home or Amazon Alexa. These allow for the users to control the speaker with their voice, but it also allows for setting of timers, reminders or can be set up to control other devices such as lighting.

The next most popular smart home device is a smart thermostat with 6% of the population owning one. The main benefit of a smart thermostat is the ability to control heating from your phone anywhere you go, because of this they are connected to the internet. They are marketed as being able to save you money as they allow for greater heating control and can learn to adapt to your routine or can let you set up routines.

The Hive smart thermostat has the largest market share at 52%. The next biggest competitor is Nest which has 15% market share and the rest are various other companies such as Honeywell(4%), Tado(2%) and Wave(2%), amongst others.

Smart lighting is owned by 5% of the population. Smart lighting allows for the control of lighting from your phone or other device and allows for different colours of lighting. Many lighting systems can be set up with the smart speakers to be the controller. Philips hue has the largest market share at 31% while Hive has 29%.

Lastly there is security, with only 3% of the population having a smart home security device. These are things like CCTV and alarms but they are all connected to the internet of the house and can be viewed on a phone or other device. The Ring doorbell is the most popular smart security device with 10% market share.

2.5.2 Demographics

While smart home devices are becoming more popular there are still 77% of the population that do not own any smart home devices. This represents a large opportunity for growth within the market as the majority of people are possible customers with no brand loyalty or investment in competitors products. The smart device that the general population is most comfortable with is smart speakers most likely in part to massive companies such as google and amazon marketing their smart speakers heavily.

The income of people with smart speakers are designated as “high income individuals”. That is to say they make over £30,000 a year. 52% of people who own a smart speaker are these high earners. So we can see the majority of people who own these types of products are reasonably rich. 65% said that they sometimes splash out on expensive things, so they are open to buying expensive things every now and again. They are mostly ages between 25-44.

Of people who own smart speakers, 58% of them believe that technology is a force for good. These are people who are reasonably tech literate and want to use technology to help them improve their life. They have a favourable view of technology and are willing to try out new technology.

The data shows that the main users of these sorts of smart home devices are relatively rich people who are willing to spend a large amount of money on an item, who also have a favourable view of technology and believe it can help them in their life.

2.5.3 Features

Identifying the most and least used features can give an insight into what motivates people to buy these smart house systems while also identifying ways in which we can differentiate our product.

There are various different features that smart thermometers offer and various rates of which people use them. Of the people who have a smart thermometer, 72% said that they use the smart thermometer to control the heating, as you would expect. 44% of users use the remote control via the app. Other features such as hot water control and frost protection are used at reasonably high rates of 29% and 31% respectively. While other features such as geolocation, where the system knows if your home or not and gives you notifications based on your location, and multi-zone heating controls are used much less at 11% and 4% respectively. The people using these systems may not even know they have these features built into the systems.

2.5.4 Perception

Most people who own smart home devices are satisfied with their purchase. 72% of people are satisfied with their hive systems and 66% are satisfied with their Nest system. More people would recommend Nest, at 66%, whereas Hives recommendation rate is at 56%. While most people would recommend their system, there is still a sizable portion that would not. This suggests that there is room for improvement with these devices that would boost the recommendation rates.

Hive is a more present brand than the others as its awareness level is 54% just over double of the next biggest competitor nest at 26%. While Hive has a higher consideration score of 11% against Nest's 3%. More people are aware of Hive and Hive is brought to mind more when they are asked about smart thermostats.

As for perception of smart devices in general, 75% of people who do not own a smart home device are aware of them. 12.13 million people would be open to buying and using a smart home.

One major issue with smart devices people have is the threat of cyber attacks and the security of the data. People have become more and more aware of how their data is used and how susceptible it is to being stolen.

While a lot of people do not have a smart home device and do not see the need, they can still be convinced and there is a sizable portion of the population that are open to buying one. If someone already has a smart home device they are more likely to buy another one. Therefore convincing them will be significantly easier than trying to market to someone who does not have one or want one. People's concerns about security allows for an opportunity to allow them to control the data themselves and give consumers more autonomy with the data they generate.

(All statistics provided by youGov 2018)

2.5.5 Competitor analysis

<u>Competitors</u>	<u>What is it good at</u>
Hive	Controlling heating remotely
Nest	Heating Control
smartThings	Timers, works with many devices
Philips hue	Lighting controls
Ubiquiti	Security cameras

Hive:

The market leader with 52% of the smart thermostat market, this is the biggest competition. Hive is the most marketed of these smart home solutions, and the most well known. Hive is most well known for their smart thermostat, the ability to “control your heating, from your phone”. They also have Hive plugs, that allow for appliances to be turned on or off remotely, and motion sensors for security. The Hive hub is required to connect all of the Hive products together. The Hive thermometer lets you control the heating and displays the heating. It lets you control the heating with your voice too. Hive supports heating, lighting and security. Hive’s flagship bundle is the “Hive active heating” which is priced at £179 and comes with the thermometer, a hub and a hive receiver. The bundle is sold without the hub for £99. Hive lights range in price from £19 to £44. Hive security packs come in a variety of configurations with different amounts of cameras, sensors and types of cameras (indoor or outdoor), all ranging in price from £259 to £409. Radiator valves are sold in packs of 3 or 5 at £139 for 3 and £199 for 5. Hive sactiver plugs are £109 for 3 and £159 for 5.

The target market for Hive is families who live in a house. The images around their website are all of the kitchen or living rooms of a house that evidently has children. They also have “customer stories” which are titled “the X family”. Evidently their target market is families with kids. The pictures throughout the website shows larger more modern houses and with the pricing structure denotes a target market of middle class families with children as their target market.

Hive uses a “When, While, Then” structure for user created actions. It also has a set of preset actions and allows for schedules to be set up using the app. It also uses geolocation to allow for notifications when the heating has been left on.

Nest:

The google owned Nest is the second largest smart thermometer with 15% of the share. They are the second largest but still small compared to Hive. However, more people would recommend Nest at 62%, whereas Hive is at 56%. Nest's awareness is at 26% rather than Hive's 54%.

Nest's products include a hub, smoke alarms, security, and speakers and entertainment. A prominent feature of their marketing is the savings of users of their smart thermostats. The Nest system automatically learns your schedule by when you turn the heating on or off. They claim that it "programs itself" after just one week of useage. The app allows for the controlling of the temperature remotely and gives alerts if there are issues with the temperature of boilers or pipes. It has a "Leaf" rewards system. This is the gamification feature where when the thermostat is adjusted to an energy efficient level it will give you a leaf as a reward. The leaves get harder to obtain over time as the requirements for what is energy- efficient get narrower and narrower over time to help you get into the habit of adjusting the energy to the optimum level and to help you reduce the cost of heating. Nest Gives monthly home reports based on the energy usage. It shows you how much you have used, how much has been saved and provides suggestions on how to use less energy.

The nest Hub is priced at £59 with the max version being significantly more expensive at £199. The thermostat is priced at £169. Nest indoor cameras are £129 each with the outdoor cameras being £149.

The target market is similar to Hive, featuring large modern houses and families with children.

SmartThings:

Samsung's SmartThings immediately has integration with all of their products. Samsung phones and tvs can be used together without the hub, however the hub allows for the control of more things. The SmartThings hub is priced at around £70 (prices vary on vendor). SmartThings is compatible with many different devices, not just samsung devices. Ring doorbell devices, yale locks, amazon echo or google home, philips hue and aurora smart lights, smart plugs and it works with honeywell and netatmo thermostats and radiator valves. Along with different wireless speaker systems and samsung home appliances such as robot vacuums and washing machines.

SmartThings has motion sensors that allow for everything in a room to be turned off when you leave or turned on when you enter, along with a schedule feature

SmartThings marketing does not seem to target any one specific group but a few. The smartThings website has a helper widget in which it asks who you live with and what type of accommodation you live in. Options include on your own, with a partner or friend or as a family and for accomodation it has an apartment or house. The website does not have any photos of a house or living space; instead it is all drawings and the living situation, if a family or friends living together is left out. This implies they are not trying to target one specific group, like what Hive and nest are doing by targeting families exclusively.

2.6 PESTEL analysis

2.6.1 Political

The UK government is aiming to reduce greenhouse gas emissions to net zero by 2050 and with the passing of the Climate change act 2008 they have the powers to introduce necessary measures to achieve this goal.

Corporate Tax was reduced to 18% as of 1st april 2020. This reduction will mean a small portion of money will be saved and can be used on more marketing efforts or other uses inside the organisation.

Brexit is a major geopolitical event that will affect the economy and the UK for years to come. There is no guaranteed way to predict the ways in which it will affect the UK economy. However, experts have warned that the UK economy will be worse off outside the European Union, GDP will drop and trade will be more expensive and people may lose jobs and therefore not have as much disposable income. People and organisations will be more wary of the amount of money they are spending due to the uncertainty.

2.6.2 Economic

With the spread of Covid-19 around the world we have seen multiple countries' economies take a big hit and many companies have lost a large percentage off of their stock prices. Indexes such as the NASDAQ, Dow Jones, and the FTSE 100 have all seen a large downturn in recent months. With some markets losing 50% of their value. The trend right now is that of a recession. A recession will mean that consumer and B2B spending will decrease. As incomes and revenue fall, companies and people will want to save money and conserve their spending. This will limit the amount that companies and people will be willing to spend on items they perceive to be superfluous.

If consumer and corporate spending is decreased the likelihood of individuals or companies buying our product will be decreased as it may be deemed non essential.

2.6.3 Social

With the Green movement gaining traction in the UK over the past few years, more and more people are becoming aware of their carbon footprint and are more sensitive to environmental issues. Products that can aid in reducing carbon emissions are likely to be perceived well by climate conscious people. But they will be cautious as they will care about the company behind the product's carbon footprint too.

A large issue over the past few years has been data security and protection, and ownership of user data. With large companies such as equifax having their data breached, customers are worried about the way in which their data is stored. They are also sensitive to what the data is being used for. With the likes of google taking and using location data and facebook taking data for advertising, users want to know what is being done with the data they are giving companies and what data they control.

2.6.4 Technological

The development of smart devices that are capable of recording, sending and receiving data has allowed the smart home market to exist. Without the development of smart light bulbs such as philips hue and smart radiator valves the idea of a smart home could not be possible. With the introduction of more smart devices into the home the ability to control a wider range of devices will be possible. If the Uplink system is updated regularly the number of compatible devices can be increased.

2.6.5 Environmental

Similar to the social factor the creation of this product will have to be ethical while also being from a sustainable source. As a focus of the product is about environmentalism the product itself must be created to these standards.

2.6.6 Legal

Marketing in the United kingdom has to follow the rules set out by the government. The marketing we create will need to follow these guidelines of being an accurate description of the product, truthful, decent, legal, and socially responsible. There are different regulations between broadcast and non broadcast media.

UK Data protection laws which are very similar to the GDPR regulations. Any information we store about customers will have to be stored in accordance with the rules set about in the data protection act 2018. Since the user's data is stored on the device the only information we will be storing will be the personal information when people sign up to our website to purchase the uplink system.

2.7 SWOT analysis

Swot analysis is used to help understand what differentiates our product and what might prevent our product from performing well in the market.

Swot analysis comprises 2 different components, internal and external. With Internal components being strengths and weaknesses. And the external components being Opportunities and threats.

2.7.1 Strengths

These are advantages that our product has and the resources we have to help.

- Privacy
 - The data the product collects is left on the device so hacking it or intercepting the data will be harder. People will have direct access and control of the data
- Versatile product
 - The Uplink system allows for compatibility with many different smart products
- Data visualisation
 - Visualising data allows for a more digestible understanding of the heating and electrical usage situation in the home.
- Different user profiles
 - Uplink is an adaptable product and can be changed to suit the users needs

2.7.2 Weaknesses

These are improvements we could make, the factors affecting our goals and limitations we may have

- New players in an already established market
 - As a new company it is harder to break in and gain customers as a lot of the market has already bought a competitor's product
- No brand loyalty or existing customer base
 - As a new company there is no existing customer base to rely on, use to spread good word of mouth or no customer stats to use as part of advertising.
- Only a team of 5 so far
 - Limited in the amount of experience

2.7.3 Opportunities

These are things that the competition are not doing that we could do or where are there gaps in the market not being serviced by competitors

- Privacy is big concern
 - Capitalize on privacy concerns as they are a hot button issue right now.
- Plenty of people not with smart home devices yet
 - Lots of households do not have a smart device. Big section of the population that could buy the Uplink system
- Lots of people are aware of smart devices
 - This section of the population needs just a little more of a push to buy a smart home system.
- Non families households are not marketed to.
 - competitors marketing is mostly aimed at households with a family of parents and kids. The other household types are not marketed to nearly as much.
- Economic Recession
 - Market the product as a cost saving product that helps you save money in the long run

2.7.4 Threats

These are market conditions and what competitors are doing better than us.

- Hive already has large market share
 - Hive is main competitor and they are biggest player in the market
- Competitors increasing compatibility
 - Reduced our strength
- A recession
 - People will be much less willing to spend money
- Cost of marketing
 - Depending on the form of marketing it could cost more to market than originally thought.

2.8 Marketing plan

2.8.1 Target Market

The target market for the Uplink system is young families of the middle and upper classes. These people are likely to be tech literate, they keep up to date with the latest technology and feel like technology is a good thing and they also have some disposable income to spend, however they remain cost conscious of the heating bills. As they are relatively young they are aware of the environmental impact they have and are conscious about their carbon footprint. These people most likely have a consistent schedule with work and school.

A secondary target market is young professionals ages 25+. These people are tech literate as they grew up with technology and they are environmentally conscious. They have some disposable income being professionals and they are conscious about the bills too. Nobody likes spending money they don't have to.

2.8.2 Unique selling point

The unique selling points of the uplink system are that the detailed and dynamic data can be shown at any point. Giving the users a more detailed look at the usage of their electrical devices and heating on demand. The inclusion of the solar panel data allows for the offset of energy used and energy gained to be shown in an intuitive manner. Data is shown in a succinct and data rich manner making it easier to understand and interpret.

The users data is kept on the device on internal storage and is not kept on a central company server. Users are aware of the security concerns with giving their data over to a company. With several large companies being hacked in recent years and having user data stolen. People are also more aware of why companies are storing your data and what they use it for. Google is known for collecting a lot of data about their users and using it for targeted advertisements. In recent years companies such as Apple have released advertising campaigns where they ensure customers that the data on their phones is theirs and is secure.

It is safe to say that security has become a top concern of people recently. Leveraging customers' worries about who has access to their data and what it is being used for can mean we can create a unique selling point. This unique selling point is that our product does not collect data on users to be sent to a central location, to be data mined or used for advertising.

2.8.3 Marketing mix

2.8.3.1 Product

Our product is the Uplink Hub, a device that allows for devices throughout the house to be controlled from the users hub or their phone, while in the house or outside.

A product can be broken down into 5 layers:

Core Benefit: This is the fundamental need or want that is satisfied by your product. For Uplink this is saving money on household heating and electricity bills.

Generic Product: This is the minimum viable product that allows it to function. This would be the charts and statistics of the devices and being able to turn devices off remotely and have it tell you when you're spending or using too much.

Expected product: This is the set of features a customer expects when they buy the product. This would be the ability to easily find the statistics you want and to turn off devices remotely easily with just a button press, be able to set timers and that it is relatively easy to set up devices. The device should also come with some storage to allow for the storing of historical data.

Augmented Product: This is the additional features and benefits. This is the ability to set up different rooms with set devices in it, more storage to allow for more data to be stored and

Potential Product: This is what the product could be in the future after undergoing augmentation or transformation. This could be more features in the future and updates that increase the functionality, such as being compatible with more devices or more accurate readings.

2.8.3.2 Place

The product will be sold online from our own website, direct to consumers, to eliminate the retail margin. Uplink units will be sent from the producer to a storage warehouse to await a customer order. From there customer orders will be sent via a shipping company such as Hermes or UPS.

2.8.3.3 Price

The Uplink hub will be priced at £200. This is priced around the same price range as the other main competitors. Ancillary products could be bought to increase the functionality of the Uplink hub, such as more storage space to allow for more historical data to be stored. The larger the amount of storage the larger the cost, E.g a 32GB storage upgrade costing £30, 64GB costing £55, 128GB costing £100. The pricing model will incentivise buying a larger capacity by creating a greater capacity to pound ratio at the higher end, therefore increasing revenue.

2.8.3.4 Promotion

The marketing will mostly take the form of promoted posts on platforms such as instagram, facebook, twitter and youtube. This will allow for our marketing to be targeted towards our target demographic. Social media advertisements are significantly cheaper than TV adverts.

Use of sales promotions could be employed to increase sales at certain times. These promotions could involve bundling more storage space with the hub or bundling certain 3rd party devices, that are compatible, with the Uplink hub. These could be deployed at certain times to drive sales such as when the product launches to encourage early adopters and during christmas.

Tech reviewers and comparison websites hold a lot of power. People look to them for guidance with their buying decision. Review units will be sent out to tech publications, youtubers and websites for review purposes. Honest reviews are always received better than paid for adverts thinly veiled as reviews. WE will send review units for free and ask that they make a review of the product. This will create a large amount of awareness and positive search results when people search for our products.

2.8.4 Positioning

Positioning the product is how you place your product relative to others in the market. Such as Apple's iphone being the high end premium luxury product. To properly position a product we must consider 4 aspects, Push, Pull, anxiety and habit. The first two , push and pull move customers towards your product, whereas anxiety and habit move customers back towards your competitor.

Push is what makes a customer leave their current solution and move to your solution. It is essentially how our competitors can't do certain things. In our case, it is not easy to see the trend data of your heating or cost on the app. You must log onto the browser version of the app to see the trend data. Alternatively they may not even be able to see historical data.

Pull is how these missing features impact the users experience negatively and why they will switch to you. The ability to see the trends and see when you are spending money on heating when not in the house or at a certain time of the day can be invaluable to being aware of the cost of heating.

Anxiety is the concerns that the customers will have about switching to your product. Such as what is done with the data and the overall benefit of the product. Telling users the data is stored on their device and is theirs to do what they want with and showing the benefits including cost savings and utility of the product can help mitigate this factor.

And habit is the pull they have to the old system as they are familiar with it and the tedious process of setting up and learning a new system. This can be mitigated by showing that our app is intuitive and easy to set up.

2.8.5 Marketing materials

The marketing materials involved with this campaign will be primarily social media posts with short promotional videos that we can use to show our product in use.

2.8.6 Avenues

The bulk of the marketing activities will take place on social media platforms. This allows for a larger more targeted campaign at our target market. As our target market is younger people they most likely use social media, facebook, twitter, instagram etc. Social media marketing has a versatile advertising system that shows ads to the specific people we want to see our ads based on criteria we define. For example we can show our ads to people between the ages of 25-45 who have kids. Facebook advertising allows for a “lookalike audience” which finds a similar audience to the one we want to target directly. This will mean we can spend less money on advertising and the advertising we do will be directed at the people who are most receptive to our advertising and fits our demographics.

This form of marketing allows for us to create a large amount of impression and create large exposure. The use of hashtags means we can also target our advertisements to specific keywords and the groups of people who would be browsing that hashtag. Interacting with customers also creates a more relatable and approachable brand image. People who have a positive interaction and perception of a brand are more likely to buy products from them. Social media allows for our brand to be seen as approachable, friendly and open to interactions with potential customers.

Social media marketing is also a lot cheaper than traditional advertising such as TV. Having a greater return on investment means the marketing budget we have can go further and be more effective.

Social media marketing also allows for us to track more accurately how effectively the advertising is. The metrics that social media marketing gives you are more detailed, including click through rate, how many impressions the post got and the amount of time it was viewed for. We can more accurately track our goals for the campaign and adjust the strategy if the adverts are not being as effective as anticipated.

2.8.7 Alternate avenues

An alternative source of revenue could be government contracts for heating and energy control systems for buildings. As the government is trying to reduce the amount of pollution and save money they may try to contract companies to try to help them create systems to reduce the energy usage in government buildings.

The government may also contract companies to make a new generation of smart meters and incentivise people to get them. With a new generation of smart meters the government could use them as a way to help reduce the consumption of energy across the country.

References

YouGov, 2018, The dawn of the connected home, available at :

http://campaign.yougov.com/rs/060-QFD-941/images/YouGov_UK_2018_08_smart_homes.pdf

3 High Level Overview

3.1 Product Overview

Our product is targeted towards two groups:

1. Home-owners looking to upgrade their property to a smart, eco-efficient home
2. Property managers overseeing a portfolio of smart homes

Our product is 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 is 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 home-owners

We partner with home builders to provide our system as standard when purchasing a new, eco-efficient home. The system will be based around a U-HUB ('Uplink HUB') which will communicate with the device ecosystem, record smart data and provide the homeowner with an interface to view and configure their smart home.

We also provide these smart devices and our U-HUB aftermarket for home-owners looking to introduce our smart ecosystem to their home.

The system provides the homeowner with a one-stop-shop to control devices and view reports from around their smart home. It allows 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 allows the home-owner to divide their devices and reports into rooms, making it easier to get the data they need, when they need it.

For the community

Uplink's long-term plans are for our U-HUBs to be able to connect to a wider network of HUBs, allowing home-owners to choose data they want to publish publicly and give a community-wide insight into the environmental levels within their area.

We believe open data is vital to understanding and offsetting harmful behaviours, and in a world of increasingly limited resources, knowing where we need to focus our developmental efforts regarding power usage, building materials, etc.

3.3 HUB Environment

The U-HUB System is hosted upon a small single-board computer provided to the customer to connect within their home network. The device runs a light-weight version of Linux such as Raspbian (although the System will also run in Windows and OS X environments, for developmental purposes). The device will have a small screen to aid in its initial setup.

The interface provided by the System is available to any devices on the network provided their internet browser supports JavaScript ECMAScript 5 (2009) or above. All browsers have supported this standard [since 2013](#).

The technologies used to build the system are as follows:

Device	
Linux	Operating System
Back-end	
Node.js	Primary server language
SQLite	Data storage
Mosquitto	Broker for relaying MQTT messages sent between devices and the HUB
JSON	For database and front-end / API communication
Front-end	
Vue.js	Responsive JavaScript library
JSON	For back-end / API communication
Development Tools	
Visual Studio Code	Light-weight Microsoft source-code editor
GitHub	Version Control System
BSS	Bootstrap Studio for the company website

4 Detailed Overview

4.1 Front-end Development

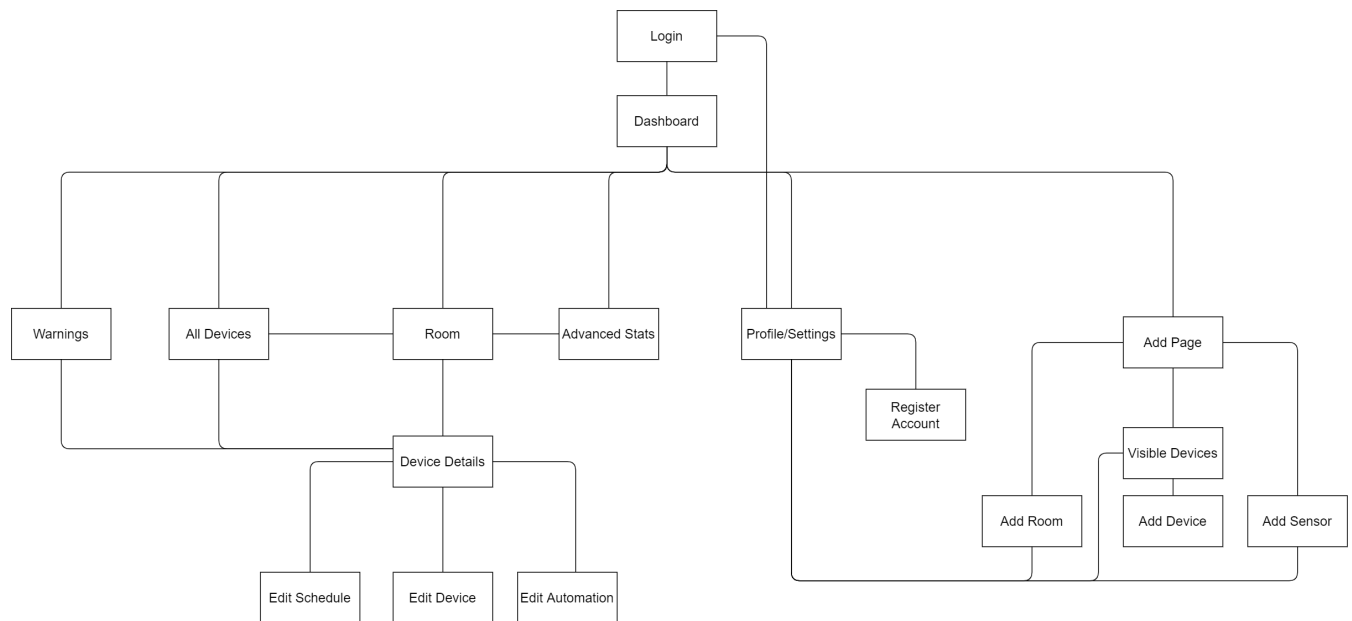
A considerable amount of the front-end has been developed using Vue.js:

- Majority of the Home-owner view has been completed.
- Forms for adding/deleting - Timers, Triggers, Rooms, Devices, Accounts and Sensors have been completed.
- Secure login system that uses cookies to keep users logged in.
- Routing system to allow for hyperlink usage to navigate the applications pages
- Fully responsive and elegant design.
- All connections to the back-end fully working.

4.1.1 Front-end Design Principle

The System's front-end / interface has been developed following modern design patterns in the industry, with a mobile-first approach being taken from the beginning. We expect the vast majority of our end-users to be interacting with the System from a smartphone or tablet device, so we believe this was important to get right. Of course, the interface still works flawlessly on bigger screens too, such as laptop or desktop devices.

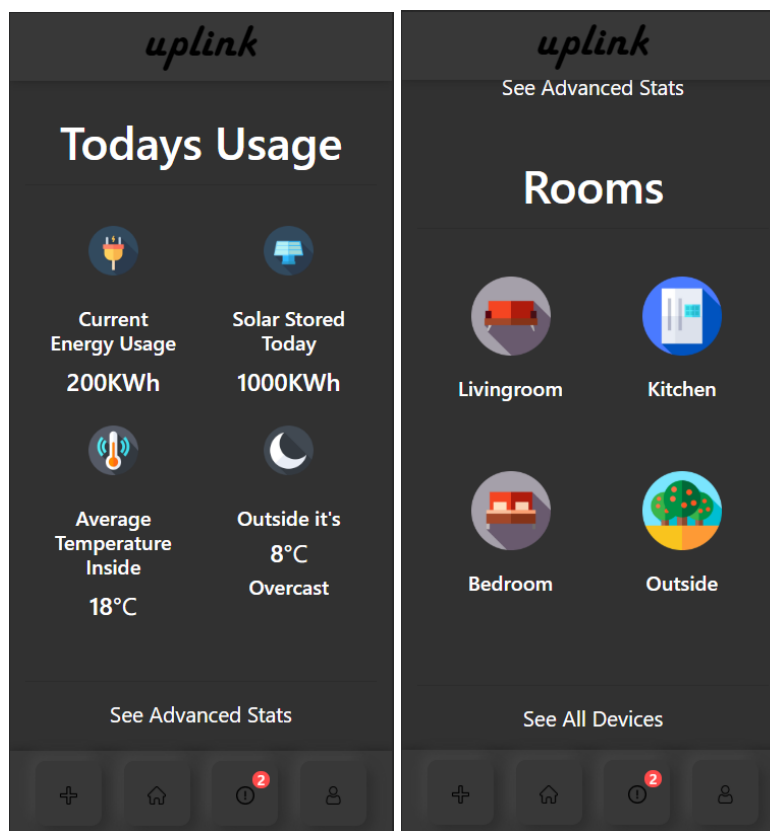
4.1.2 Site Map



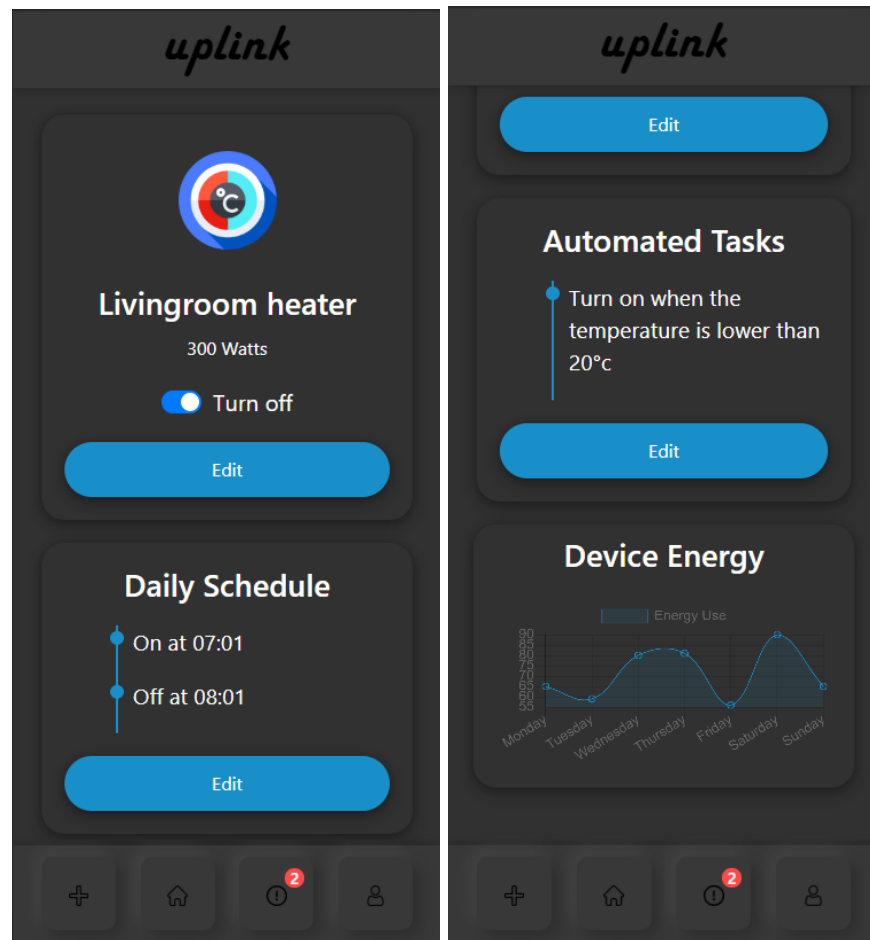
This site map gives an overview of the applications structure. The user must login first to be able to view or control anything within the application. From the Dashboard you are able to access all the main pages via the navigation bar or with links to the desired pages. Although all pages except the Login page have access to the navigation bar (navigation links to Warnings, Add Page, Profile/Settings and the Dashboard) for clarity these page connections have been removed.

4.1.3 Final Application Interface Design

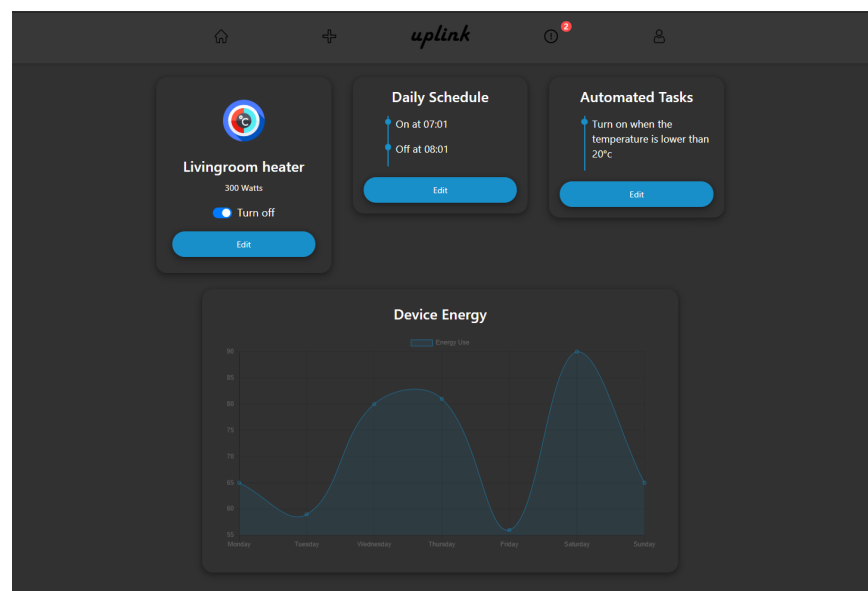
The final design of the applications interface was created to be simple and easy to use for all age groups. We designed pages and forms to be intuitive and simple to grasp. Each page featured organised information about certain rooms or devices and made use of the space available on the screen in a consistent manner. The interface is fully responsive and works consistently on all screen sizes. Certain aspects of the design changes between the mobile and desktop versions. These design changes were made to make the application more user friendly. Below are a few screenshots that reflect the final interface design for the Uplink Home Hub App:



[Fig. 3: Final Mobile Dashboard Design]



[Fig. 4: Final Mobile Device Details Page Design]



[Fig. 5: Final Desktop Device Details Page Design]

The system uses cookies (Vue-Cookies) to keep users logged in to the application. The cookie stores the authentication token required to access the API. The front-end application used many fetches to send and receive data to and from the API. These requests used JSON as the standard of data transfer between front-end and back-end of the System.

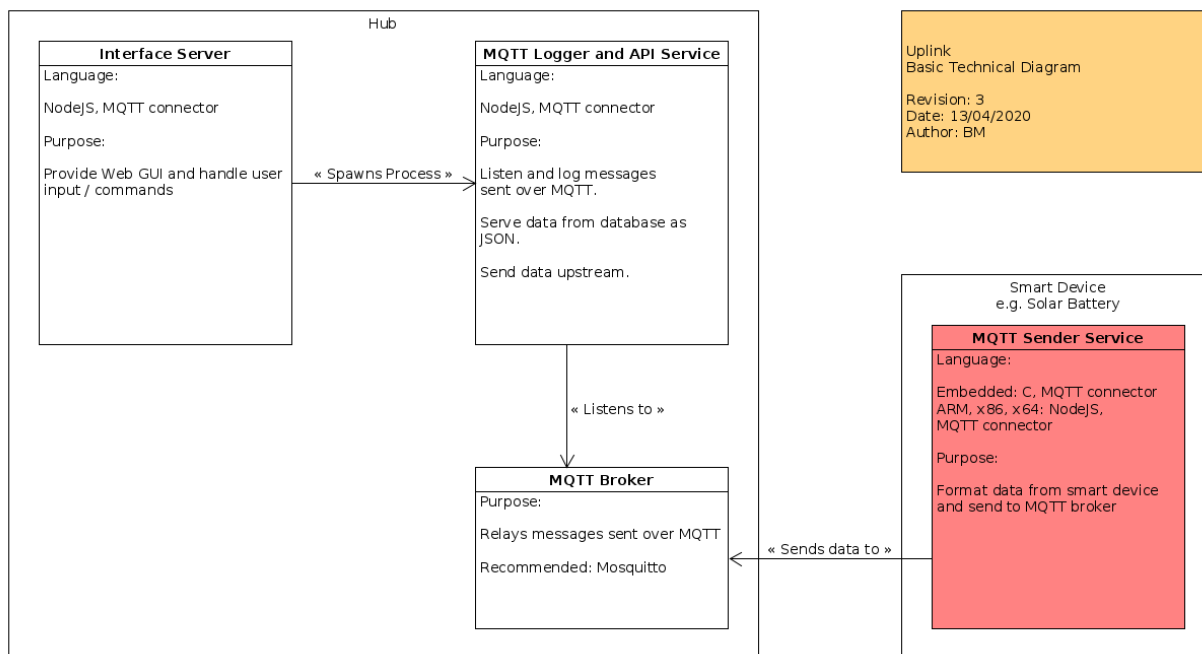
The charting library used to show and present data from the back-end was Chart.js. We chose this library to use as it provided dynamic and responsive charts that we could use without much alteration or additional programming.

Certain interfaces have been generated dynamically to keep the design of the app simple and consistent. Pages like the Room Page and the Device Details Page have been generated dynamically as they generally revolve around showing the same data for a room or a device respectively. Although pages like the Device Details Page may look different per device this is only due to certain devices having the ability to do certain things (smart fridges will not have schedules whereas a smart bulb will have a schedule for when the device should turn on or off, etc). The implementation of this interface using dynamically generated pages did speed the development of the front-end up.

4.2 U-HUB Functionality

4.2.1 Overview

The U-HUB as a System is composed of multiple modules that run in tandem, and are shown below, along with their purpose and language.

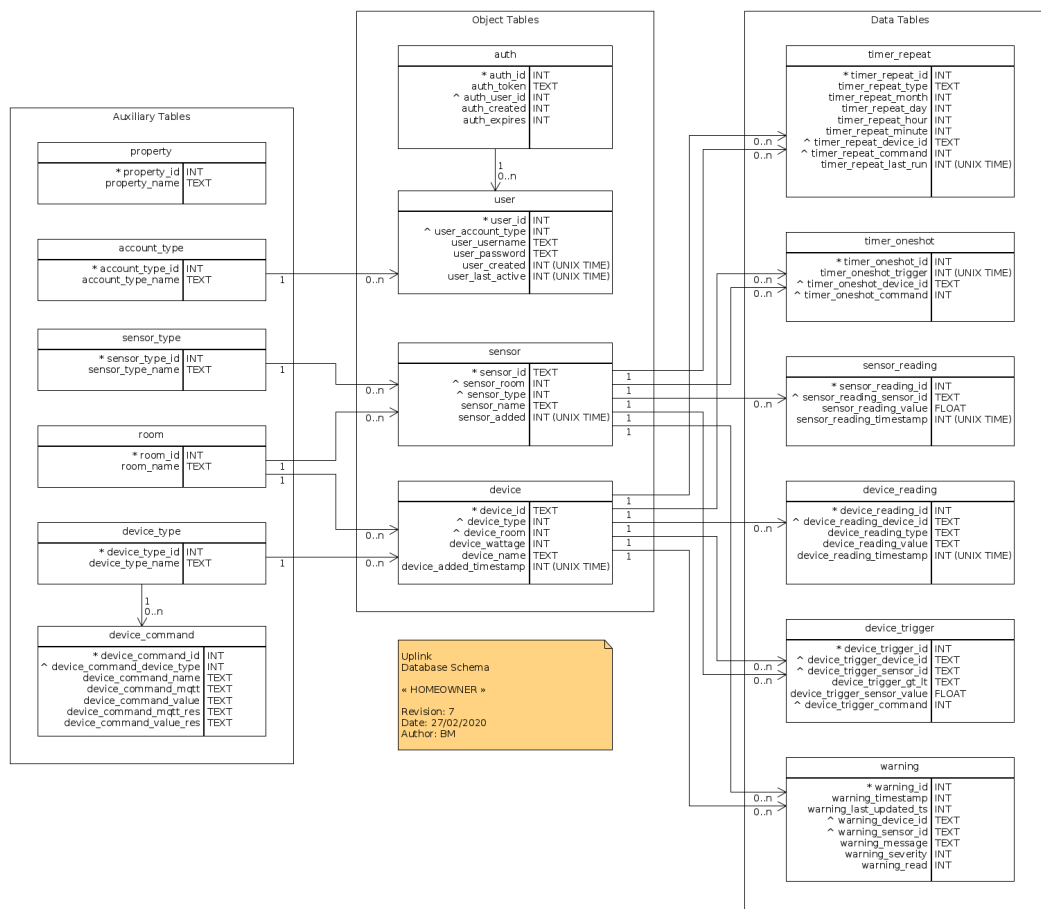


The development of the 'MQTT Sender Service' - software which runs on individual smart devices / sensors - was not commissioned by the Customer for this project, but has been loosely defined. The addition of third-party protocols such as Philips Hue's API is planned for later development.

4.2.1 Data Storage

The U-HUB has a range of fantastic functions and abilities, and a lot of work has gone into making sure this device can sit at the centre of a home for as long as needed, while remaining useful and secure. One of our driving principles throughout development has been that of privacy - not a luxury, but a *right* that many internet-enabled devices do not reserve for their end-users. For that reason we have developed our U-HUBs to function completely offline, if necessary, and to store data locally. Later on, the option to back-up data to the cloud will be added for users that wish for the added reassurance.

Below is the database schema implemented by the U-HUB which stores all information, from device instances, user details and data readings. The database file itself can be quickly and easily backed-up onto an external device from the U-HUB's built-in interface, as we use **SQLite** which runs alongside our software, not requiring an external SQL server.



4.2.2 Security

The U-HUB interface will respond to any device on the local network, however with simple tweaks to an end-user's home router, the U-HUB can be accessed from anywhere, even outside the home. And the user needn't worry - the U-HUB implements strict log-in authentication for this purpose, even locally.

We use token-based authentication to protect our U-HUBs. Each device will come with a pre-setup Admin account which the end-user can use to set up other accounts and permissions. Whenever a user is signed in, a token is generated and stored with the U-HUB which must be submitted with every request from the device, to make sure it is still a valid session. If the user logs out, or the session expires, the token is removed and becomes invalid.

The use of token authentication means that not only is the device secure when exposed to the internet, but it also allows hobbyists and tinkerers an easy way to interface with their U-HUBs.

Something else we think is important is getting everyone - and we mean, everyone - involved in proactively monitoring their energy usage. That's why our U-HUBs support multiple user accounts with **different permissions**. Admin accounts have the ability to change what devices a user account can interact with. That means, for example, a child can have access to only the devices in their own room, while being able to see the sort of effect their devices have on the whole home's energy efficiency.

4.2.3 Devices and Sensors

When an end-user wishes to connect a new device they must attach it to the U-HUB first via a cable or contactless if supported. The U-HUB will then allow the user to add this device, requiring they name it and assign it to a Room. This information is then stored in the database, and the device is assigned a unique ID which is used to identify it over the network. The same process is used for connecting sensors, which are seen as slightly different from devices for internal reasons.

The unique ID and network address of the U-HUB is then written to the device / sensor in order for it to begin communicating with the HUB over MQTT, a lightweight messaging protocol. Every message received by the U-HUB is stored in its internal database.

While *sensors* simply report data, the user can interact with *devices* in a multitude of ways, listed below:

- **Schedule** device commands for a specific time, such as turning a light on at 9:00am in the morning.
- The classic - remotely turn the kettle on from bed.
- Set up **triggers** for devices, such as turning the heater on when a sensor reads a temperature below 15°C.
- Set up **one-shot** and **repeat timers** to send commands to devices at the specified time.
- Edit, move and rename a device.

4.2.4 Reports

The big one. The U-HUB stores the data received from all of the home's devices, and can use this to generate graphs and reports on a whole-property, per-room or per-device basis. We provide the user reports with energy consumption, temperature, humidity and even money spent. In fact, we can graph any number a sensor can spit out.

It is important to give the end-user the clearest, most accessible way to view their information. The user needn't trail through the back-menus to find their data - it is provided for them in the same Room or Device view as they would navigate to simply to interact with their devices.

Our graphs are generated using the live data from the U-HUB fed into Chart.js, a lightweight JavaScript library perfect for less powerful mobile devices. The information is retrieved from our authenticated API, which allows hobbyists a way to fetch this data themselves and display it however and wherever they want.

4.2.5 Notifications and Warnings

The U-HUB is ultimately designed to help the owner live a more eco-efficient life at home. To help it do that, the U-HUB implements notifications which can alert the user to urgent warnings about things within the home, such as a device being left on too long or the temperature dropping too low. At the moment, these warnings are built-in to the software, but later they will be configurable through the interface in a similar fashion to triggers and timers.

Thanks to the web-based interface, we're able to make use of Web-Push notifications, meaning that any device with a modern browser can receive push notifications, similar to native Android / iOS / Windows notifications, straight from the U-HUB. The end-user does not have to enter the app to discover how they could be making more efficient choices - or learn what could be wasting their money!

The browser will prompt the users to subscribe their device to these notifications, so they can be enabled on some devices and not others. This can of course be disabled, too. The subscriptions are all stored in the U-HUB's database, and it supports as many device subscriptions as they would like.

If the U-HUB is configured for access outside the local home network, then the notifications will work anywhere with internet access.

4.2.6 Automation

As previously mentioned, the U-HUB supports **triggers** and **timers**. These two fantastic functions allow the home to self-automate, reacting to the changing environment within and outside the property.

Cold in the kitchen? The home can sense that, and shut the windows.

Humid in the bathroom? The U-HUB will turn on the extractor fan.

The possibilities for **triggers** are endless despite how easy they are to configure. The end-user simply selects the device they would like to add a trigger to, selects the sensor value they'd like to react to and the command to set off should that value rise or drop below what they have specified. The U-HUB checks triggers and timers on a minutely basis, so it rarely misses a beat.

Timers are quite self-explanatory! The end-user can set up commands for their devices to execute at given times of the day, on a daily, weekly or monthly basis. This is great if you always forget to turn the lights off at night, or want to have the kettle heating as you're getting out of bed.

Timers and triggers are both stored in the U-HUB's database, and can be backed up in the same way as the rest of the user's data.

4.3 Back-end Development

The back-end consist of a few components, running in tandem thanks to JavaScript's asynchronous nature.

- Receiving and logging data from the MQTT broker,
- Checking for and generating warnings,
- Checking triggers,
- Checking timers,
- Responding to API calls.

4.3.1 Authorization Header

Most API calls require an Authorization header to be sent along with the request. This must take the form:

Authorization: {token}

The token is obtained by submitting valid username and password credentials to the /login endpoint. It consists of a randomly generated string concatenated with the ID of the user the token is authenticating, and then base64 hashed for web transmission like so:

{user_id}:{randomly generated string}

1:Ab123-134AN-234GB-3948D-28Bdw

Produces the Auth token:

MTpBYjEyMy0xMzRBTi0yMzRHQi0zOTQ4RC0yOEJkdw==

4.3.2 API Definitions

Unauthenticated

All API calls besides those listed below require an Authorization header to be sent containing the token generated upon a successful log in.

The un-authenticated URIs are listed below:

URI	/
Request Type	GET
Purpose	Get status of the U-HUB API service
Parameters	
Response	
“Uplink HUB API running”	

URI	/login
Request Type	POST
Purpose	Get status of the U-HUB API service
Parameters	username, password
Response	
{ “token”:{token} }	

Push Notifications

URI	/getVapidKey
Request Type	GET
Purpose	Get the public VAPID key used for encrypting web-push notifications
Parameters	
Response	
<pre>{ "public_vapid_key":{public_vapid_key} }</pre>	
URI	/subscribe
Request Type	POST
Purpose	Subscribe the browser to web-push notifications
Parameters	Subscription object
Response	
URI	/unsubscribe
Request Type	POST
Purpose	Unsubscribe the browser from web-push notifications
Parameters	Subscription object
Response	
URI	/unsubscribeAll
Request Type	POST
Purpose	Delete all web-push notification subscriptions for that user
Parameters	user_id
Response	

City

URI	/getCityById
Request Type	GET
Purpose	Get city info by its ID
Parameters	id
Response	
<pre>[{ "city_id":1, "city_name":"Tokyo", "city_lat":35.685, "city_long":139.7514, "city_country":"Japan" }]</pre>	
URI	/getSimilarCities
Request Type	GET
Purpose	Performs a wildcard search of city names with the text provided and returns info
Parameters	id
Response	
<pre>[{ "city_id":1, "city_name":"Tokyo", "city_lat":35.685, "city_long":139.7514, "city_country":"Japan" }, {...}]</pre>	

Trigger

URI	/getTriggerById
Request Type	GET
Purpose	Get all info on a trigger
Parameters	id
Response	
<pre>{ "device_trigger_id": "1", "device_trigger_device_id": "123ABC123", "device_trigger_gt_lt_eq": "eq", "device_trigger_sensor_value": "20", "device_trigger_command": "1" }</pre>	
URI	/getTriggers
Request Type	GET
Purpose	Get all trigger info
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ "device_trigger_id": "1", "device_trigger_device_id": "123ABC123", "device_trigger_gt_lt_eq": "eq", "device_trigger_sensor_value": "20", "device_trigger_command": "1" }, {...}]</pre>	
URI	/insertTrigger
Request Type	GET
Purpose	Create a new trigger
Parameters	deviceId, sensorId, symbol, value, commandId
Response	
<pre>{ "rowId": "1" }</pre>	

Sensor

URI	/getSensorTypeById
Request Type	GET
Purpose	Get the sensor type by the id
Parameters	id
Response	
<pre>[{ "sensor_type_id":{id}, "sensor_type_name":{type} }]</pre>	
URI	/getSensorById
Request Type	GET
Purpose	Get a sensor by its ID
Parameters	id
Response	
<pre>[{ "sensor_id":"ABC123", "sensor_room":1, "sensor_type":1, "sensor_name":"Livingroom temp sensor 1", "sensor_added":1579521113 }]</pre>	
URI	/getSensorByRoom
Request Type	GET
Purpose	Get the sensors in a given room
Parameters	room
Response	
<pre>[{ "sensor_id":"ABC123", "sensor_room":1, "sensor_type":1, "sensor_name":"Livingroom temp sensor 1", "Sensor_added":1579521113}, {...}]</pre>	

URI	/getSensorTypes
Request Type	GET
Purpose	Get all sensor types
Parameters	
Response	
<pre>[{ "Sensor_type_id":1, "sensor_type_name":"Temperature" }, {...}]</pre>	
URI	/getSensors
Request Type	GET
Purpose	Get all sensors
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ "sensor_id":"ABC123", "sensor_room":1, "sensor_type":1, "sensor_name":"Livingroom temp sensor 1", "Sensor_added":1579521113 }, {..}]</pre>	
URI	/getSensorReadings
Request Type	GET
Purpose	Get all sensor readings
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ [varied JSON response for different sensor types] }, {..}]</pre>	
URI	/insertSensorType

Request Type	POST
Purpose	Create a new sensor type
Parameters	name
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/insertSensor
Request Type	POST
Purpose	Create a new sensor
Parameters	room, type, name
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/editSensor
Request Type	POST
Purpose	Edit an existing sensor
Parameters	id, room, type, name
Response	
<pre>{ "rowId": "1" }</pre>	

URI	/getSensorReadingsByTimeframe
Request Type	GET
Purpose	Get sensor readings between a start and end time
Parameters	id, start, end
Response	
<pre>[{ [varied JSON response for different sensor types] }, {..}]</pre>	
URI	/deleteSensorType
Request Type	GET
Purpose	Delete a sensor type
Parameters	id
Response	
1	
URI	/deleteSensor
Request Type	GET
Purpose	Delete a sensor and optionally its data
Parameters	(optional) data (true/false)
Response	
1	
URI	/deleteSensorReading
Request Type	GET
Purpose	Delete all of a sensor's readings
Parameters	
Response	
1	

Device

URI	/getDeviceTypeById
Request Type	GET
Purpose	Get a device type's info by ID
Parameters	id
Response	
<pre>[{ "device_type_id":1, "device_type_name":"Heater" }]</pre>	
URI	/getDeviceById
Request Type	GET
Purpose	Get a device's info by ID
Parameters	id
Response	
<pre>[{ "device_id":"123ABC123", "device_room":1,"device_type":1, "device_wattage":300, "device_name":"Livingroom heater", "device_added":1579521113 }]</pre>	
URI	/getDeviceByRoom
Request Type	GET
Purpose	Get all devices in a room
Parameters	room
Response	
<pre>[{ "device_id":"123ABC123", "device_room":1, "device_type":1, "device_wattage":300, "device_name":"Livingroom heater", "device_added":1579521113 },{...}]</pre>	

URI	/getDeviceTypes
Request Type	GET
Purpose	Get all device types
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ "device_type_id":1, "device_type_name":"Heater" },{...}]</pre>	
URI	/getDevices
Request Type	GET
Purpose	Get all devices
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ "device_id":"123ABC123", "device_room":1, "device_type":1, "device_wattage":300, "device_name":"Livingroom heater", "device_added":1579521113 },{...}]</pre>	
URI	/getDeviceReadings
Request Type	GET
Purpose	Get all devices readings
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ [varied JSON response for different device types] }, {..}]</pre>	

URI	/insertDeviceType
Request Type	POST
Purpose	Create a new device type
Parameters	name
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/insertDevice
Request Type	POST
Purpose	Create a new device
Parameters	room, type, name, wattage
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/editDevice
Request Type	POST
Purpose	Edit an existing device
Parameters	id, room, type, name, wattage
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/getDeviceReadingsByTimeframe
Request Type	GET
Purpose	Get device readings between a start and end time
Parameters	id, start, end
Response	
<pre>[{ [varied JSON response for different device types] }, {..}]</pre>	

URI	/deleteDeviceType
Request Type	GET
Purpose	Delete a device type
Parameters	id
Response	
1	
URI	/deleteDevice
Request Type	GET
Purpose	Delete a device, along with associated timers and triggers and optionally device readings
Parameters	id, (optional) data (true/false)
Response	
{ "status":"success" }	
URI	/deleteDeviceReadings
Request Type	GET
Purpose	Delete all triggers associated with this device
Parameters	id
Response	
1	
URI	/deleteDeviceTrigger
Request Type	GET
Purpose	Delete all triggers associated with this device
Parameters	id
Response	
1	

Room

URI	/getRoomById
Request Type	GET
Purpose	Delete a room's info by the corresponding ID
Parameters	id
Response	
<pre>[{ "room_id":1, "room_name":"Livingroom" }]</pre>	
URI	/getRooms
Request Type	GET
Purpose	Delete all room info
Parameters	
Response	
<pre>[{ "room_id":1, "room_name":"Livingroom" }, {...}]</pre>	
URI	/insertRoom
Request Type	POST
Purpose	Create a new room
Parameters	name
Response	
<pre>{ "rowId": "1" }</pre>	

URI	/deleteRoom
Request Type	GET
Purpose	Delete a room
Parameters	id
Response	
1	

User

URI	/getUsers
Request Type	GET
Purpose	Get all user data
Parameters	(optional) limit, (optional) offset
Response	
<pre>[{ "user_id":1, "user_account_type":1, "user_username":"Test_user", "user_email":null, "user_forename":null, "user_surname":null, "user_created":1579521113, "user_last_active":"1579521113", "user_admin":1 }]</pre>	
URI	/insertUser
Request Type	GET
Purpose	Create a new user
Parameters	Account_type, username, password, email, forename, surname, admin
Response	
<pre>{ "rowId": "1" }</pre>	
URI	/editUser
Request Type	GET
Purpose	Edit an existing user
Parameters	account_type, username, password, email, forename, surname, admin, id
Response	
<pre>{ "rowId": "1" }</pre>	

URI	/insertUserPermission
Request Type	GET
Purpose	Grant a user permission to a device or sensor
Parameters	user_id, (device_id OR sensor_id)
Response	
{ "rowId": "1" }	
URI	/deleteUser
Request Type	GET
Purpose	Delete a user
Parameters	id
Response	
1	

Warning

URI	/getWarnings
Request Type	GET
Purpose	Get info on all warnings
Parameters	id
Response	
<pre>[{ "warning_id":13, "warning_timestamp":1584025169139, "warning_last_updated_ts":1586898316256, "warning_device_id":"123ABC123", "warning_sensor_id":null, "warning_message":"This heater has been on for over 2 hours!", "warning_severity":3, "warning_read":0 }, {...}]</pre>	
URI	/deleteWarning
Request Type	GET
Purpose	Delete a warning
Parameters	id
Response	
1	

Command

URI	/execute
Request Type	GET
Purpose	Instantly execute a device command
Parameters	commandId, deviceId
Response	
1	
URI	/getCommandsByDevice
Request Type	GET
Purpose	Get all commands for a specific type of device
Parameters	id
Response	
<pre>[{ "device_command_id":1, "device_command_device_type":1, "device_command_name":"Turn on", "device_command_mqtt":"set_power", "device_command_value":"on", "device_command_mqtt_res":"status", "device_command_value_res":"on", "device_type_id":1,"device_type_name":"Heater" }, {...}]</pre>	
URI	/deleteDeviceCommand
Request Type	GET
Purpose	Delete a command by its ID
Parameters	id
Response	
1	

Timer

URI	/getRepeatTimers
Request Type	GET
Purpose	Get all repeat timers for a specific device ID
Parameters	id
Response	
<pre>[{ "timer_repeat_id":1, "timer_repeat_type":"Day", "timer_repeat_month":1, "timer_repeat_day":1, "timer_repeat_hour":7, "timer_repeat_minute":1, "timer_repeat_device_id":"123ABC123", "timer_repeat_command":1, "timer_repeat_last_run":0 }, {...}]</pre>	
URI	/getOneshotTimers
Request Type	GET
Purpose	Get all oneshot timers for a specific device ID
Parameters	id
Response	
<pre>[{ "timer_oneshot_id":1, "timer_oneshot_trigger":"1579521113", "timer_oneshot_device_id":"123ABC123", "timer_oneshot_command":1, }, {...}]</pre>	

URI	/insertRepeatTimer
Request Type	GET
Purpose	Create a new repeat timer
Parameters	type, month, day, hour, minute, device_id, command
Response	
{ "rowId": "1" }	
URI	/insertOneshotTimer
Request Type	GET
Purpose	Create a new repeat timer
Parameters	trigger, device_id, command
Response	
{ "rowId": "1" }	
URI	/deleteRepeatTimer
Request Type	GET
Purpose	Delete a repeat timer
Parameters	id
Response	
1	
URI	/deleteOneshotTimer
Request Type	GET
Purpose	Delete a oneshot timer
Parameters	id
Response	
1	

5 Development Process

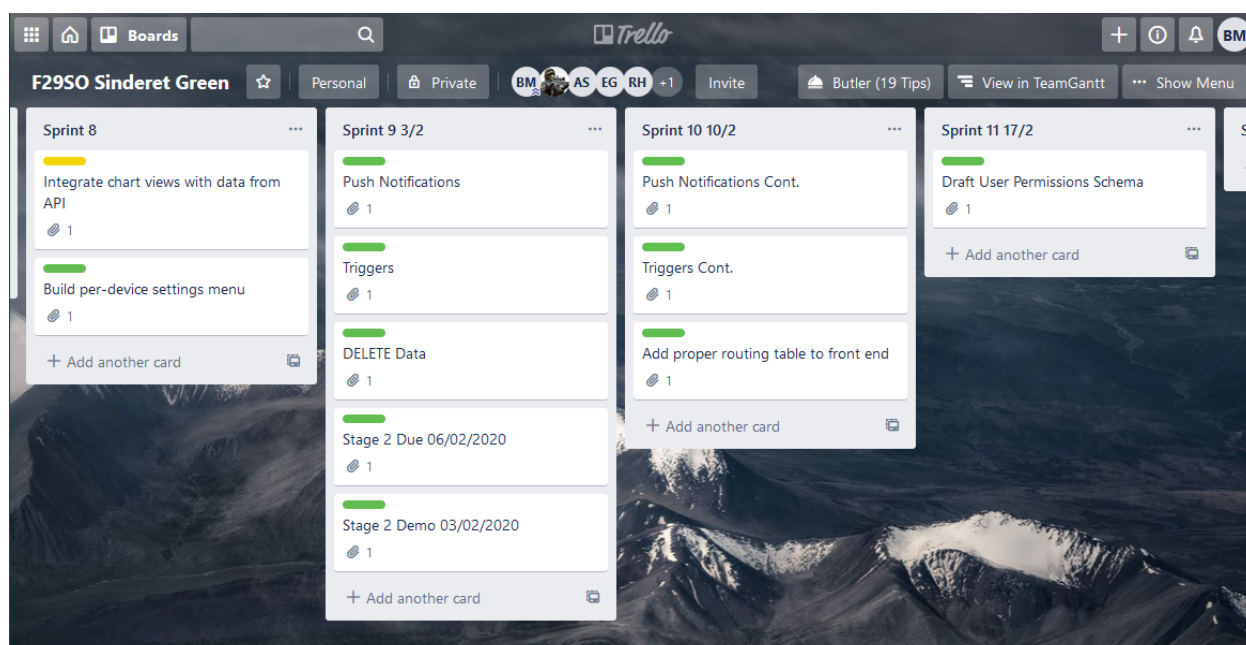
5.1 Methodology

We used a few different methods to aid us when planning our short and long-term development process.

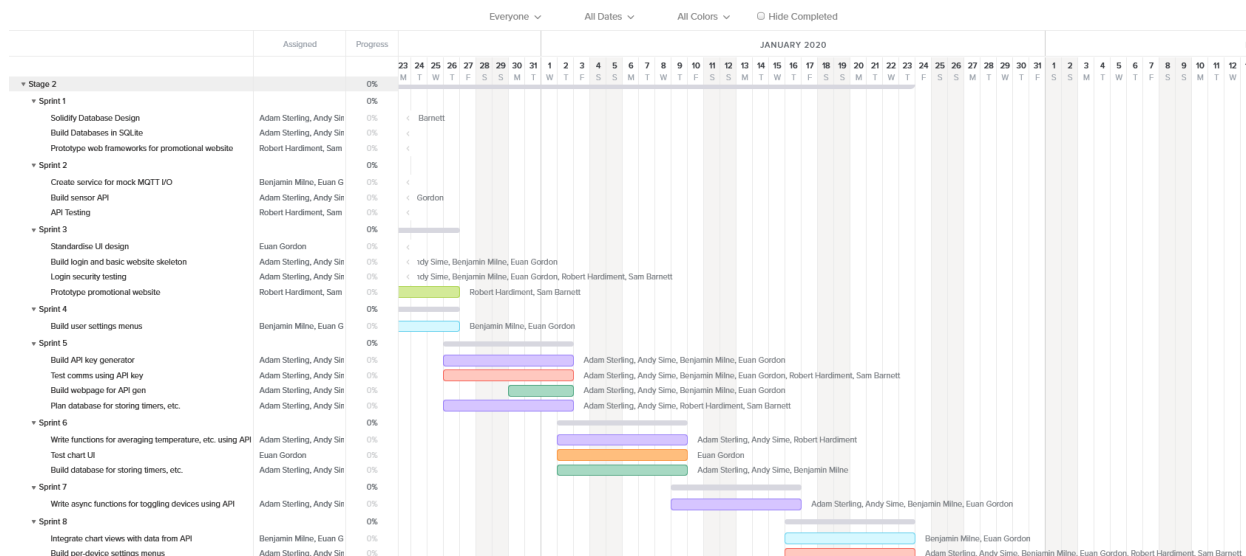
We used a common mixture of Agile and SCRUM approaches to development, implementing week-long sprints which would include development and unit testing. The Uplink team met regularly to discuss progress and as such, sprints were occasionally rearranged to allow for re-development of units or more time allotted to testing.

We found that due to the busy schedules of Uplink members, week-long sprints allowed for enough flexibility as to when the members could work on the project.

To keep a track of progress, we used the popular virtual kanban board [Trello](#), and exported that into a [TeamGantt](#) gantt chart to more easily divy up tasks to each team member for the initial phases.



[Trello Kanban Board]



[TeamGantt Gantt Chart]

5.2 Schedule

Below is a sprint-by-sprint breakdown of the tasks planned for each sprint / week.

Stage 1		
Sprint	Date Span	Planned Implementation
1	28/11 - 05/12	Solidify schema and build databases Prototype frameworks for promotional website
2	05/12 - 12/12	Create mock MQTT service Build sensor API API testing
3	12/12 - 19/12	Standardise UI design Build login and basic website skeleton Login security testing Prototype promotional website
4	19/12 - 26/12	Build user setting menus Complete overflow tasks
5	26/12 - 02/01	Build API key generator (later referred to ask a Token) Test comms using API key Plan a database for storing timers, etc.
6	02/01 - 09/01	Write functions for averaging temperature, etc. Test chart UI Build a database for storing timers, etc.
7	09/01 - 16/01	Write async functions for toggling devices using API Complete overflow tasks
8	16/01 - 23/01	Integrate chart views with data from API Build per-device settings menus

Stage 2		
Sprint	Date Span	Planned Implementation
9	23/01 - 03/02	Implement push notifications Implement triggers Implement delete data functions
10	03/02 - 10/02	Complete push notifications Complete triggers Add proper routing table to front-end
11	10/02 - 17/02	Draft user permissions schema Complete overflow tasks
12	17/02 - 24/02	Implement user permissions
13 & 14	24/02 - 09/03	Focus on bug testing Tidy up software Begin documentation
15, 16 & 17	09/03 - 30/3	Bug fixing Compile final report

6 Testing

6.1 Front-end Testing

Across all sprints completed, to test for technical correctness we continuously integrated the front-end with the back-end and on achieving correct responses from the back-end we can say that the front-end is technically correct. For parts of the front-end that did not require a connection to the back-end we created simple tests to assure that these functions were designed and implemented correctly.

7 End-User Documentation

The following are installation guides that will be used to direct technicians and others to install and run the Uplink home hub application.

7.1 Technician Installation Guide

The following installation guide will not be undertaken by end users as the system (Raspberry Pi) will come pre installed with the application. This installation guide will take place by an Uplink Technician prior to install in the end users house.

The Raspberry Pi will be preinstalled with Raspbian OS.

7.1.1 Clone the GIT repository and install NodeJS:

1. Open a new Raspbian OS terminal

2. Install Node.js and NPM

```
$sudo apt-get nodejs
```

3. Use GIT to clone the Uplink Home Hub repository to the Raspberry PI

```
$git clone git@github.com:BCJMilne/F29S0-Sinderet-Green.git
```

7.1.2 Set up the system's front-end:

1. Open a new Raspbian OS Terminal

2. Navigate to the directory that stores the cloned repository.

3. Navigate to the front end directory

```
$cd uplink-project-vue/
```

4. Install the necessary packages for the application to operate.

```
$npm install
```

7.1.3 Set up the system's back-end:

1. Open a new Raspbian OS Terminal

2. Navigate to the directory that stores the cloned repository.

3. Navigate to the backend directory

```
$cd hub-api/
```

4. Install the necessary packages for the application to operate.

```
$npm install
```

5. Rebuild the database on the Raspberry Pi with Node.js and better-sqlite3

```
$node main.js -r
```


7.2 Technician Startup Guide

This guide is used when the system is installed in the end users home and for the initial boot up of the system:

1. Open a new Raspbian OS terminal
2. Navigate to the Uplink System Front-end Directory.

```
$cd Documents/F29S0-Sinderet-Green/uplink-project-vue
```

3. Run the front-end server.

```
$npm run serve
```

4. Open a new Raspbian OS tab
5. Go to the back-end repository

```
$cd ../hub-api/
```

6. Run the back-end server

```
$node main.js
```

7.3 Demo Installation and Execution Guide

This installation guide is for installing and running demo data for demonstrations, maintenance or for development purposes. **This guide should be used by the examiners when testing the Uplink Home Hub.**

7.3.1 Linux

7.3.1.1 Clone the GIT repository and install NodeJS:

1. Open a new Terminal
2. Install Node.js and NPM

```
$sudo apt-get nodejs
```

3. Use GIT to clone the Uplink Home Hub repository

```
$git clone git@github.com:BCJMilne/F29S0-Sinderet-Green.git
```

7.3.1.2 Installation and Execution Guide:

1. Open a new Terminal
2. Install Node.js and NPM

```
$sudo apt-get nodejs
```
3. Use GIT to clone the Uplink Home Hub repository

```
$git clone git@github.com:BCJMilne/F29SO-Sinderet-Green.git
```
4. Navigate to the cloned directory
5. Navigate to the front-end directory

```
$cd uplink-project-vue
```
6. Install the required packages for the front-end to operate.

```
$npm install
```
7. Run the front-end server.

```
$npm run serve
```
8. Open a new terminal tab
9. Navigate to the back-end directory

```
$cd ../hub-api
```
10. Install the required packages for the back-end to operate.

```
$npm install
```
11. Rebuild and run the back-end API

```
$node main.js -r -d
```
12. Open a browser and use url: <http://localhost:8080> to access the site via desktop otherwise use `http://<ip-address>:8080` to access using other devices on your local network.

7.3.2 Windows

7.3.2.1 Download the GIT repository and install NodeJS:

1. Open a browser and go to <https://nodejs.org/en/> and download the most recent version of node.js
2. Install the .msi file that was downloaded to your PC
3. On a browser and go to <https://github.com/BCJMilne/F29SO-Sinderet-Green> and download the zip file.
4. Open the downloads folder on your computer and extract the folder to your documents folder.

5. Open a PowerShell or Command Line window

```
windows-key + type "powershell"
```

6. Navigate to the unzipped folder in your documents
7. Navigate to the front-end directory

```
$cd uplink-project-vue
```

8. Install the required packages for the front-end to operate.

```
$npm install
```

9. Run the front-end server.

```
$npm run serve
```

10. Open a new PowerShell or Command Line window

11. Navigate to the unzipped folder in your documents

12. Navigate to the back-end directory

```
$cd hub-api
```

13. Install the required packages for the back-end to operate.

```
$npm install
```

14. Rebuild and run the back-end API

```
$node main.js -r -d
```

15. Open a browser and use url: <http://localhost:8080> to access the site via desktop otherwise use `http://<ip-address>:8080` to access using other devices on your local network.

7.4 Maintenance Guide

This guide is used by a technician to deal with database and notification subscription warnings.

7.4.1 Database Errors

1. Navigate to the back-end API directory - hub-api using a Terminal
2. If back-end API is running then terminate execution

```
ctrl+c to stop execution
```

3. Rebuild the database from the last saved instance.

```
$node main.js -r
```

7.4.2 Notification Subscription Errors

1. Navigate to the back-end API directory - hub-api using a Terminal
2. If back-end API is running then terminate execution

```
ctrl+c to stop execution
```

3. Delete all subscriptions from the database

```
$node main.js -cs
```

7.4.2 Device Warning Errors

1. Navigate to the back-end API directory - hub-api using a Terminal
2. If back-end API is running then terminate execution

```
ctrl+c to stop execution
```

3. Delete all warnings from the database

```
$node main.js -cw
```

7.5 User Guide

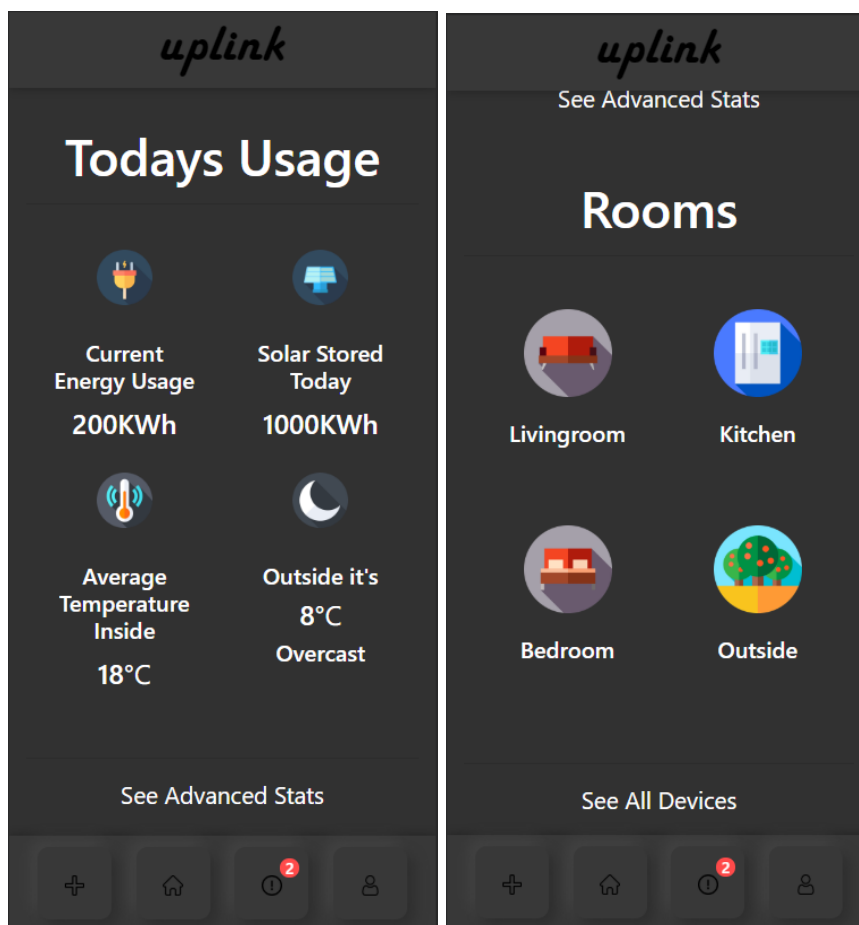
The following is a basic user guide about what the user can do on each page. Every page features a navigation bar that can take you to anywhere in the application.

The system can be used on any device - mobile or desktop. There are no differences in user actions between mobile and desktop versions. The only difference between mobile and desktop versions is the layout of each page.

7.5.1 Home/Dashboard

The Home/Dashboard page provides (top to bottom):

1. Data reflecting the whole home's energy usage, solar energy storage, average temperature in the house and the current outside weather.
2. Quick access link to advanced statistics about energy storage and expenditure.
3. Quick access links to all the rooms logged on the application.
4. Quick access link to all the devices logged on the application.
5. Navigation bar with links to adding items (rooms and/or devices), home page(current page), warnings (notifications) and to the user profile/settings page.

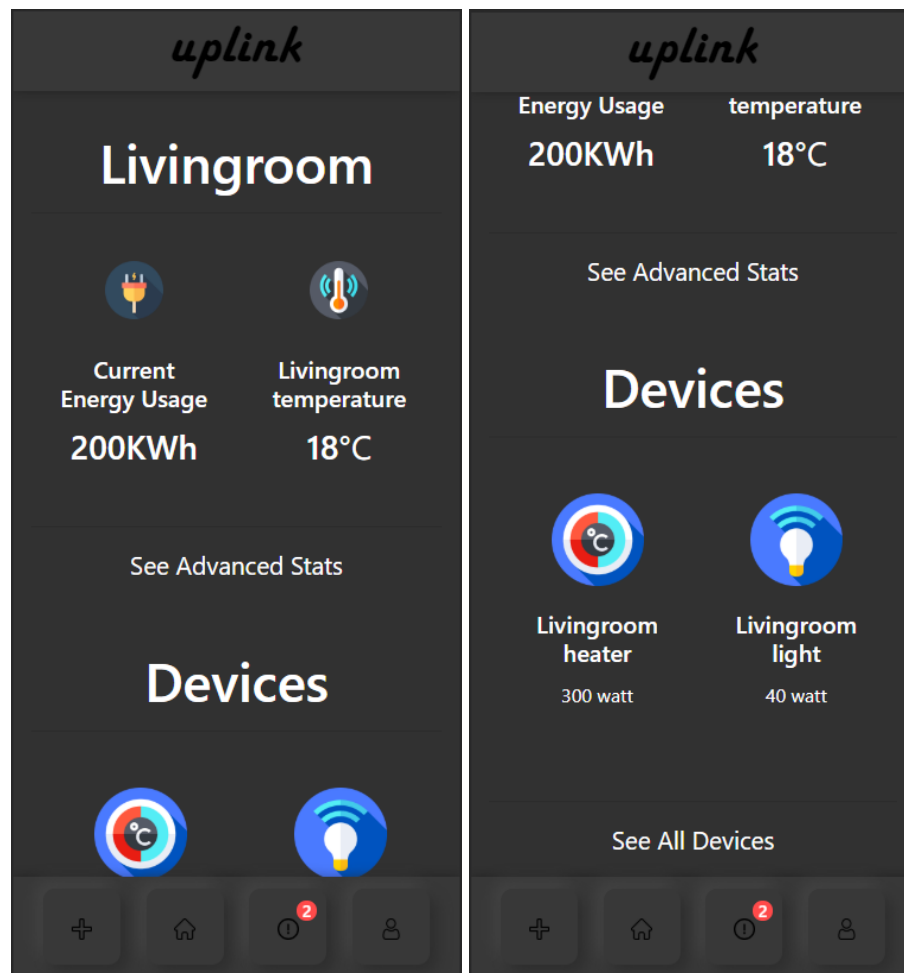


[Fig. 7: Home/Dashboard Page]

7.5.2 Room Pages

Each room page takes on the same layout. Each room page provides (top to bottom):

1. Data reflecting the rooms current energy usage and the rooms current temperature.
2. Quick access link to advanced statistics about energy storage and expenditure.
3. Quick access links to the device details in that room.
4. Quick access link to all the devices logged in the application.
5. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.



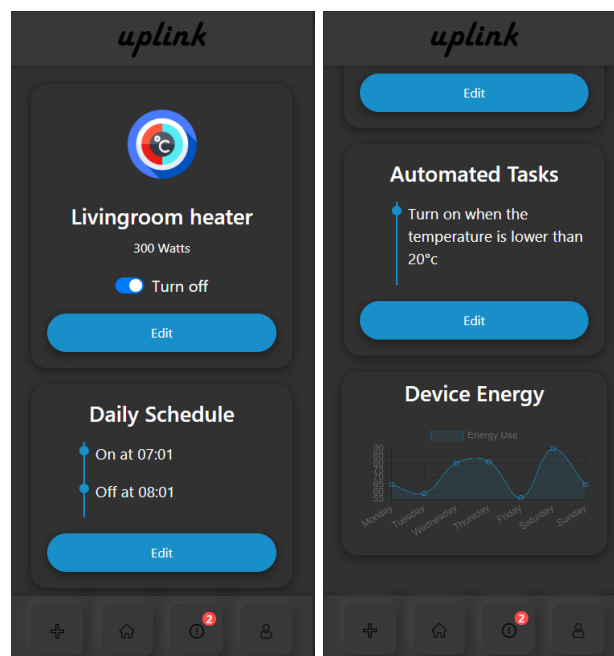
[Fig. 8: Room Page]

7.5.3 Device Details

Every device details will feature different sections depending on the device type and what options each device has (smart fridges will not have schedules whereas a smart bulb will have a schedule for when the device should turn on or off, etc).

The following device page (Livingroom heater) provides (top to bottom):

1. The first card that will show the device power requirements followed by an on and off switch for the device. This card also has a button that will take you to an edit device page.
2. The second card shows the daily schedule of when the device will be turned on or off. This card also has a button to take you to the edit schedule page.
3. The third card shows the automated tasks that the device has and a button to take you to an edit automations page.
4. The last card will show you a detailed graph of the devices energy use over the past week.
5. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.



[Fig. 9: Device Details Page (Livingroom Heater)]

7.5.4 Warnings/Notifications

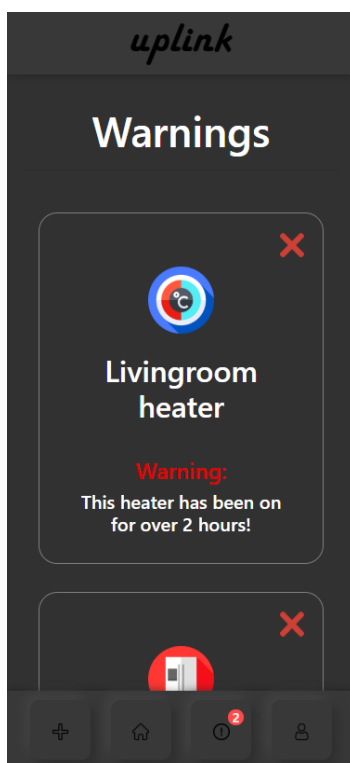
The warnings page which will display every warning that the Uplink Home Hub detects. These warnings include:

- A device has been left on for a considerable amount of time
- A device has been using a considerable amount of energy over the day.
- A device is exhibiting unusual energy readings.

The Uplink Home Hub will notify the user if a new warning has been found via web push notifications.

The warnings page provides (top to bottom):

1. Access to notified warnings. These warnings can be clicked and will take you to the device details page for that specific device that's creating the warning.
2. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.



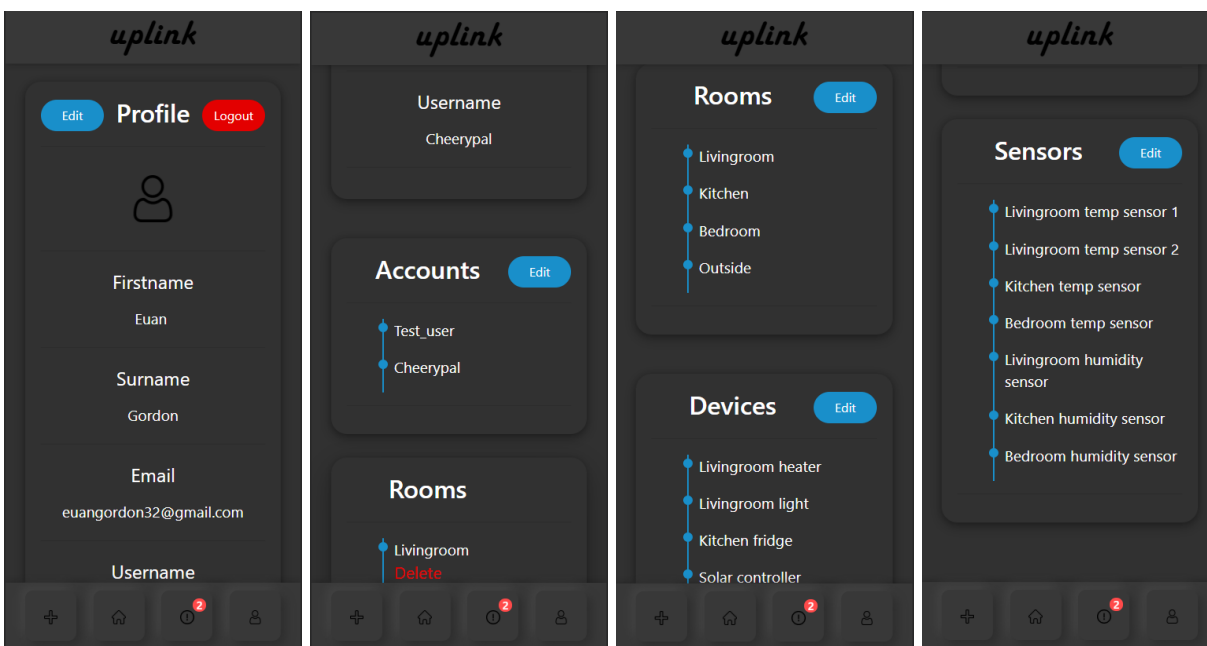
[Fig. 10: Warnings Page]

7.5.5 Profile/Settings

The Profile/Settings page is one major page that will allow you to modify anything associated with the application. You can alter the accounts, rooms, devices and sensors that the application uses.

The Profile/Settings page provides (top to bottom):

1. Edit the current users profile. Here you can click the “Edit” button to change your name, email or username. You can also click to “Logout” to logout the current user.
2. Accounts card will show you all the accounts associated with this Uplink Home Hub. You can click “Edit” to delete users or you can add more accounts. The admin user (Test_user) cannot be deleted as the application requires at least one user account for the application to operate.
3. Rooms card will show you all the rooms associated with the application. From this card you can click the button that will take you to the Add Room page.
4. Devices Card will show you all the devices associated with the application. Similar to the Rooms card you can add or delete devices.
5. Sensors Card is the same concept as the Room and Device cards with the same operations of adding and removing sensors.
6. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.



[Fig. 11: Profile/Settings Page]

7.5.6 Add Device/Room/Sensors

These add pages will allow you to add certain items to the application. Each page is specialised to a specific object that you would want to add.

The Add Room Page consists of (top to bottom):

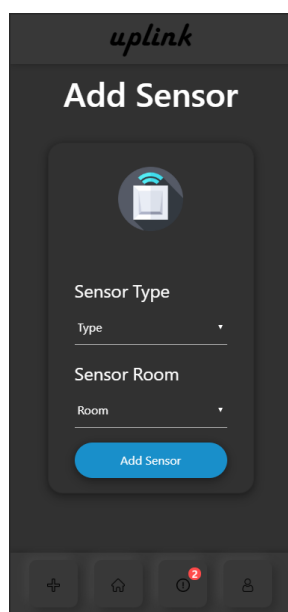
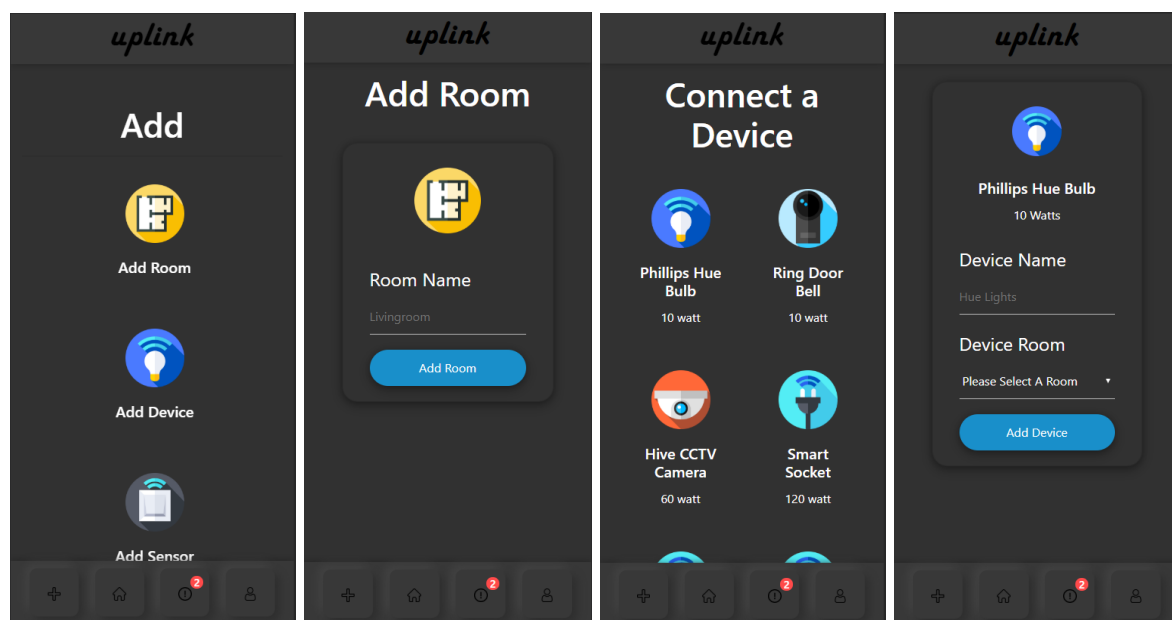
1. A simple form to add a new Room. To add a room it only requires a Room name.
2. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.

The Add Device Page is a two step process:

1. You will be displayed with all the nearby devices that can be connected to the application.
2. Once a device is clicked it will ask you to fill out a form about what you will name the device and what room the device will be placed in.
3. Both Visible Device Page and the Add Device Page will feature a navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.

The Add Sensor Page consists of (top to bottom):

1. A simple form to add a sensor to a room. To add a sensor it will require you to pick the sensor type and the room it will be placed in. If it detects a sensor of this type it will add it to the room otherwise the application will ask you to turn on the sensor.
2. Navigation bar with links to adding items (rooms and/or devices), home page, warnings (notifications) and to the user profile/settings page.



[Fig. 12: Add Room/Device/Sensor]

8 Project Evaluation

8.1 Organisation

8.1.1 Roles

Stage 1

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

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

Stage 2 and 3

Moving on to Stage 2, we adapted our roles for moving from the planning to development stage:

Role	Dept.
Branding (.COM)	
Organisational Manager, web dev.	Samual Bernett
Group Reporter, web dev.	Adam Sterling
Application	
Technical Manager	Benjamin Milne
Back-end	
Front-end	Euan Gordon
	Andrew Sime

Unfortunately one of our team, Robert Hardiment <rh187@hw.ac.uk> had to withdraw from the project. While this did not leave us immediately behind schedule, we decided to shelve the development of F-S-8 and NF-S-7, which involved implementing a Property Manager's view of a U-HUB, as this was already pushing our abilities and timescales.

However, the future implementation of this was still planned and as such development went ahead under the assumption these would be achieved after the initial release.

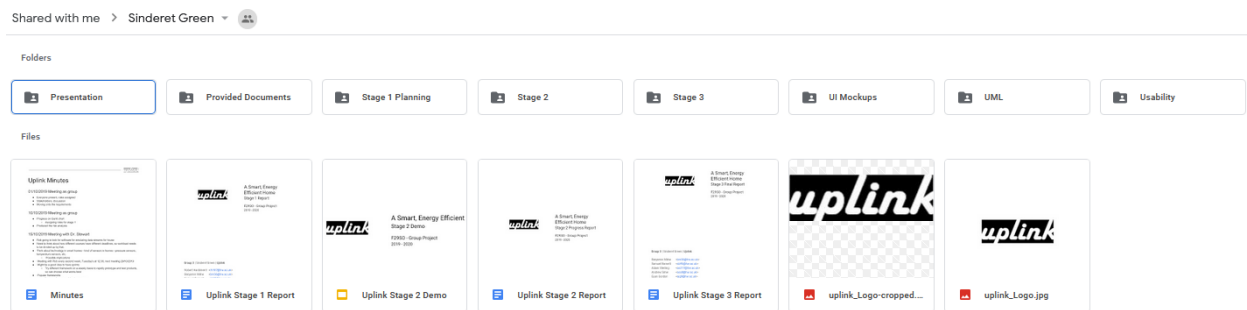
8.1.2 Effectiveness

We believe that overall the team functioned well. Members were happy with their assigned tasks as they were best suited to the member's skills, be it back-end development, web development, etc.

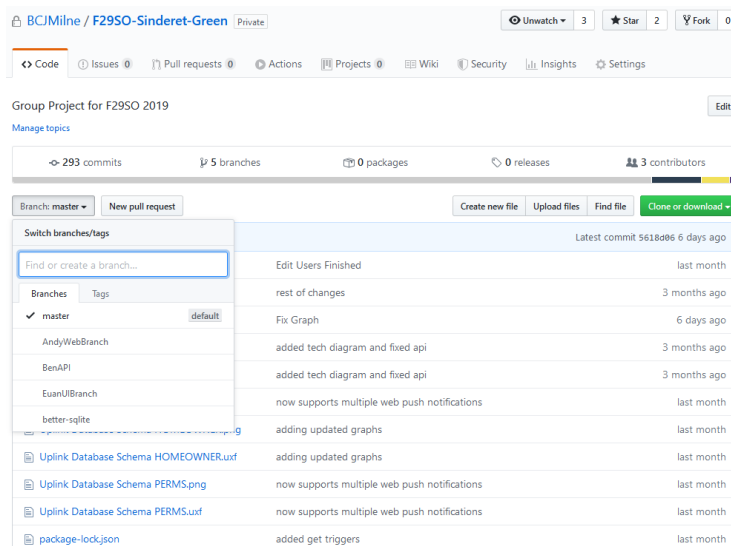
We had weekly in-person team meetings and by-weekly meetings with our Project Manager, Dr. Rob Stewart, where we discussed progress and shared ideas. We also found his contribution and direction invaluable.

Out-with meetings, we communicated regularly online via WhatsApp.

Documents including reports, meeting minutes and assets were hosted on a shared Google Drive and project code was version-controlled and hosted on GitHub, where contributing members had their own branches.



[Google Drive]



[Uplink GitHub repository, showing branches]

8.1.3 Timing

The greatest problem we came up against was Robert Hardiment having to drop out for personal reasons. Despite this, as he dropped out between stages 1 and 2, we had not yet finished assigning roles for entering proper development and as such, he was not leaving a task undone.

It did push us to drop development of F-S-8 and NF-S-7, which involved implementing a Property Manager's view of a U-HUB, as this was already pushing our abilities and timescales.

Tasks were occasionally shuffled around sprint-wise while members were absent due to holiday or illness, but for the most part the schedule we stuck to very well.

More is mentioned below.

8.2 Implementation

8.2.1 Schedule

For a breakdown of the development schedule, see [here](#).

We initially had difficulties sticking to our planned schedule during the Christmas period, placing sprints 3, 4 and 5 slightly behind. However these tasks were basic and quickly caught up on, allowing the following sprints to be completed on time.

Overall we stuck quite strictly to our schedule and found it particularly useful to see when reports and work were due in advance, and assist us in planning around that. While a gantt chart is useful for time-scales, we found using a kanban board was more flexible. We did not need to know a very specific measure of how complete a task was, so Trello's colour coding method worked well for us, e.g.

Green for 'Done', Red for 'To Do', Yellow for 'In Progress' and purple for 'Priority'.

Trello also allowed us to assign tasks to individuals, as a gantt chart would, but we usually discussed this in meetings and those who forgot could check our meeting minutes.

8.2.2 Method Success

Our approach of using a mix of Agile and SCRUM (as explained [here](#)) was very successful. It allowed for enough flexibility while keeping us on-track to get the entire project done on time. It also provided us flexibility to test throughout and for us to build-in time for overrunning tasks.

8.2.3 Tools

Product / Tool	Description / Purpose	Comments
Storage		
Google Drive	Google's cloud storage solution. Used for storage of client and Uplink files and reports. Not code.	More useful than local files for redundancy and sharing reasons. Limited version-control and automation options, so not useful for code.
GitHub	Microsoft's hub for Git VCS repositories.	Used due to member's existing familiarity and confidence in the tool, as well as widespread industry adoption.
Communication		
WhatsApp	Facebook-owned, secure instant messenger. Used for general remote communications.	Works well for groups of people communicating at once. Encrypts messages.
Email	Used for communication with the client.	Clunky but effective, everyone knows how to use it.
Planning		
Trello	Virtual kanban board owned by Atlassian.	Easy to use and cooperate on. Also, free.
TeamGantt	Virtual gantt chart.	Clunky, costly and not easy to use with multiple team members. Only used for Stage 1.
Programming Tools		
Visual Studio Code	Microsoft's script editor. Not quite a full IDE. Used by all members for the majority of coding.	Lightweight, flexible, does almost everything.
Git	Version Control System software.	Tricky for some members to get the hang of, but can be used with Visual Studio Code's integration. Useful due to branches which allowed multiple members to work on things at once.
Programming Languages and Frameworks		
JavaScript / Node.js	Majority of software is written in JS and uses Node.js to run independently of a browser.	Fast and lightweight, quick and easy to code, easy to test. Does not require compiling and limited dependencies.
HTML / Vue.js	Majority of the front-end uses HTML and Vue.js.	Vue.js allows us to dynamically generate our content using the data provided by the back-end.

8.3 Product

8.3.1 Progress Per Requirement

Below is an overview of our functional and non-functional requirements, as well as their level of completion at the end of the project.

Req. Code	Req. Explanation	Status
F-M-1	Friendly and graphical user interface	Done
F-M-2	Display and record electrical usage (in/out)	Done
F-M-3	Display and record heat levels	Done
F-M-4	Enable and disable devices	Done
F-M-5	Reminder and warning notifications	Done
F-M-6	The service should be available 24 / 7	Done
F-M-7	Available on multiple devices	Done
F-S-8	Property manager's view	Shelved
Shelved after due to lack of time and ability. This is to be developed after the initial release, so the existing project has been developed with this functionality in mind.		
F-S-9	User must be able to delete data	Done
F-S-10	Configurable users and permissions	Done
F-C-11	Calculate energy savings and difference over time	Done
F-C-12	Historical data control	Done
F-W-13	Add / configure any number of devices	Done

Req. Code	Req. Explanation	Status
NF-M-1	Logging service must record data to SQL database	Done
NF-M-2	Devices should communicate over MQTT	Done
NF-M-3	Configuration saved to persistent storage	Done
NF-M-4	API must retrieve data from SQL database	Done
NF-S-5	MQTT protocol should use WebSockets	Done
NF-S-6	Minimal / instant response time for configuring devices	Done
NF-S-7	HUB should be able to report data upstream	Shelved
See F-S-8 above.		

8.2.2 Product USPs

Our final product sets itself aside from other smart-home systems by its focus on *privacy, offline functionality* and useful functions such as *triggers*.

The following table produced for our first report highlights many of the other *Unique Selling Points* of the U-HUB product:

Functionality	Device				
	Google Home	Amazon Echo Dot	Hive Hub	Samsung SmartThings	U-HUB USPs
Turn off lights					
Thermostat control	Needs Hive or Nest	Needs Hive or Nest			
Smart plug control					
Security cameras					
Speaker control			Needs Google or Alexa		
Locking doors					
Home Appliance Integrations (washing machines etc)			Needs Google or Alexa		
Smoke detectors			Needs Google or Alexa		
Energy costs					
Solar panel energy readings					
Energy usage per device					
Advanced room temperature control					

8.2.3 Future Uplink Development

The project's next steps involve immediate work on the property manager / community views and the way in which the U-HUB communicates data with a central HUB, as required by F-S-8 and NF-S-7.

We will also develop integration with third-party devices such as Philips Hue's ecosystem, and implement ways to backup the end-user's data to a cloud storage medium such as Google Drive, OneDrive, etc.

9 End-stage Usability Study

9.1 Aims and Objectives.

The following is a detailed plan for a usability test of the Uplink Home Hub System. This section intends to highlight errors or flaws with our final system implementation by experimenting on participants of varying ages and backgrounds. The following section will not contain the results of the usability test due to the worldwide outbreak of COVID-19.

This section may be relevant to several stakeholders, not limited to but including:

1. The Uplink development team: we will use the data gathered to improve the system but to also make sure the Uplink Home Hub System meets the requirements set out in Stage 1.
2. Team Esteem: for our client to ensure that they understand the steps taken to validate that the final implementation meets their requirements.

9.2 Scope

There is one System being tested - Uplink Home Hub

The System is a web application that can be interacted with via a web browser. The System was designed and implemented to work on various devices: desktop, tablets and mobile devices.

Users, once logged in can access and interact with smart devices within their home and can view energy readings for their home and devices. Users can add schedules, automated events but also simple actions like turning a device on or off. The System allows users to manage devices within their home and group them in virtual rooms mimicking their own home.

The System depends heavily on content visualisations, rather than displaying pages of pure text. This is to:

1. Ensure content and data is presented in an easy to understand manner - suitable for all ages and levels of education.
2. Create an enjoyable user experience so that a user maintains a positive relationship with the System and will want to continue using it over the long-term.

9.3 Test Plan

9.3.1 Objective

The test will focus on assessing how the subject will interact with the final stage implementation of the Uplink Home Hub. The subject will be tested to see how easily they interact with the Systems core functionality. The subject group will be a mix of subjects that are of varying age groups and backgrounds.

The hope is that feedback gained can be used to recognise areas of improvement to our final implementation of the System.

The aims of the study are to:

- Test run the application with an individual who is part of our target market (homeowners and home residents)
- Gather quantitative and qualitative data via various forms of user-based feedback.
- Determine any issue with the usability of the final implementation.

9.3.2 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.

The participants will be asked to attempt to complete a series of tasks as effectively as possible on a version of the System. The participants will also be asked some standardised questions during the study. Participants will be asked to complete a questionnaire upon completion of the tasks. The participants will be expected to give honest feedback on the usability and functionality of the System being tested.

Each test will be conducted individually and will be supervised by a member of the Uplink Development team (member of Sinderet Green). The participant will be given some time to navigate the System on attempting each task.

9.3.3 Procedure

Participants will be taken to a convenient location by a member of the development team. Participants will be asked to sign a consent form by the member of the team and will be informed about what the test will entail. The participants will be asked to speak while they go through the tests.

The participant will then be given access to the Dashboard screen of the application and will then be given a series of tasks to complete as the team member observes. There will be no recording of the session to safeguard the participants identity.

The team member will take note of any questions or of issues that the user has. The participant will be told to ask any questions that they may have about completing any of the tasks that they are given although the team member will encourage the participant to complete these tasks on their own.

The participant will be given no prior training to the usability test. This is to ensure that our test will also emphasise the intuitivity of our final implementation of the System.

9.3.4 Collecting Data

The team member will assess the participant attempt at a task with one of these three values:

- Completed
- Required Help
 - Participant required assistance with the task. The Team member should take note of the problem encountered
- Did Not Complete

This classification system will allow us to observe user performance over the various tasks. This data will be used to calculate the following information:

Completion Rate

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

We hope that the System being tested does not contain any critical errors but if one does arise then improvement to the system implementation will be carried out after the test is concluded. The ideal completion rate is 100%.

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.

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.

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)

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

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.

9.4 Testing Protocol

To be completed by a supervising team member of Uplink.

Testing Supervisor: _____

Date: _____ **Location:** _____

Participant No. ____

Aim of this Session

Today you will be trying out a Smart Home Hub System designed for managing smart devices and monitoring device energy usage within a home. The System is in its final stage of development and your feedback will be used to improve features and the overall user interaction with this System.

Introduction

I will be asking you to interact with this System in a particular order. You should describe what you think each page is presenting and/or what each aspect of the System is asking you to do for a certain task. I will be taking notes throughout in order to record your actions or any verbal feedback you may give during the test. Any data or feedback given by you will be anonymised and cannot be traced back to you.

After the test is complete. We will provide you with a questionnaire to complete to collect any further feedback you may have on our System we have designed.

You should know that there are no right or wrong answers. Understanding your interpretation of our System will help us in improving its design.

You have the option to stop the test at any time. Please alert the supervisor if you wish to do so.

1. Dashboard

This is the landing page for users that have access to the System. This is for people who reside within the home and have an account to access the System.

1. Can you describe this page?
2. How does the colour scheme and general appearance of this site make you feel?
3. Using this page could you navigate to the Livingroom Devices?

Completed

Required Help

Did Not Complete

2. Room Screen

This page is similar to other room pages.

1. Can you describe this page?
2. Using this page navigate to the Livingroom Heater Device Page?

Completed

Required Help

Did Not Complete

3. Device Details Screen

This page will be similar to other device pages. Some device pages may not have the same content as others due to certain devices only having certain actions.

1. Can you describe this page?

2. Using this page can you turn the Livingroom Heater off?

Completed

Required Help

Did Not Complete

3. Using this page can you add a schedule item to turn the Livingroom heater on at 1:30pm?

Completed

Required Help

Did Not Complete

4. Using this page can you delete the scheduled item at 7:01am for the Livingroom heater?

Completed

Required Help

Did Not Complete

5. Using this page could you create an automated task to turn the heating on when the temperature is lower than 17°C?

Completed

Required Help

Did Not Complete

6. Using this page can you edit the device name and change it to "Central Heating" and move this device to the bedroom?

Completed

Required Help

Did Not Complete

7. Using this screen can you navigate to the "Add Page"?

Completed

Required Help

Did Not Complete

4. Add Page

This page will allow you to select an item you want to add.

1. Can you add a new room to the System called "Bathroom"?

Completed

Required Help

Did Not Complete

2. Next can you add a "Philips Hue Bulb" to the "Bathroom" you just added?

Completed

Required Help

Did Not Complete

3. Can you navigate to the "Notifications/Warnings" page?

Completed

Required Help

Did Not Complete

5. Warnings/Notifications Page

1. Can you describe this page?

2. Can you remove the warning for the kitchen fridge?

Completed

Required Help

Did Not Complete

3. Can you navigate to the “profile/settings” page?

Completed

Required Help

Did Not Complete

6. Profile/Settings Page

1. Can you describe the page?

Completed

Required Help

Did Not Complete

2. Can you delete the light bulb you added to the bathroom in stage 4?

Completed

Required Help

Did Not Complete

3. Can you delete the "Bathroom" from the application?

4. Can you edit the Test_user's details by adding a forename, surname and email?

Completed

Required Help

Did Not Complete

5. Can you navigate to the Add a New Account page?

Completed

Required Help

Did Not Complete

6. Can you complete the form with your details? These details will be deleted after the test is complete.

Completed

Required Help

Did Not Complete

7. Can you log out Test_user?

Completed

Required Help

Did Not Complete

8. Can you log in with your new account?

Completed

Required Help

Did Not Complete

COVID-19 Outbreak

Due to the current COVID-19 pandemic the usability test will not be completed by a participant due to social distancing to prevent the spread of the virus. Due to this, gathering data on errors, questions and any form of results are not possible at this time.

10 Appendix

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 final implementation of the Uplink Home Hub System.

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

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 System?

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

7. Please state your level of agreement

		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
A	The System is clear and easy to understand					
B	The System is user friendly					
C	I feel confident using this System					
D	The systems layout is logical					
E	The System is suitable for people of all ages and backgrounds					
F	The System is visually appealing					
G	I thought the System was inconsistent					
H	Some aspects of the System were complicated					
I	The System would be useful to me or people I know					

7. Do you have any additional comments?

Meeting Minutes

01/10/2019 Meeting as group

- Everyone present, roles assigned
- Stakeholders, discussion
- Moving onto the requirements

10/10/2019 Meeting as group

- Progress on Gantt chart
 - Assigning roles for stage 1
- Produced the risk analysis

15/10/2019 Meeting with Dr. Stewart

- Rob going to look for software for emulating data streams for house
- Need to think about how different courses have different deadlines, so workload needs to be divided up by that.
- Think about technology in smart homes - kind of sensors in homes - pressure sensors, temperature sensors, etc.
 - Possible implications
- Meeting with Rob every second week, Tuesday's at 12:30, next meeting 29/10/2019
- Might be a good idea to have sprints
 - Try different framework on a weekly basis to rapidly prototype and test products, so can choose what works best
- Popular frameworks
 - Node.js, Angular.js, Vue, bootstrap
- Doodle.com/robstewart to see schedule and arrange a time for meeting

24/10/2019 Meeting as group

- Euan has done use case diagram
- Will split up the rest of the diagrams (state and activity) between Andrew, Sam, Adam and Robert
 - Andy doing top 4
 - Robert doing next 4
 - Adam doing next 4
 - Sam doing bottom 4
- Ben started the LaTeX file for stage 1, and is going to keep adding to mqtt use case file
- Euan has done more work on the app design using adobe xd
- ASSUMPTIONS - smart devices are aware of their own power consumption
- Euan doing usability test - all chip in from rough plan

29/10/2019 Meeting with Dr. Stewart

- Make deadline 2 weeks in advance, suggested 14th
- Brand / market research
- Critique what each system is capable of, what we could combine
 - Samsung smart home
 - Samsung family hub
 - Google home hub
- What is clean living
 - How do you measure it?
 - Suggest cleaner living advice through hub
- Next meeting 1:15pm on the 14th
- Latex pgfgantt

07/11/2019 Meeting with group

- Robert uploading consent, ethics and questionnaire by tomorrow morning
 - Testing will involve participants carrying out tasks
 - Can determine usability by issues against frequency of issues
 - **All going to look for a subject each for Tuesday**
 - Subjects should remain anonymous through given ID
 - Adobe xd file used to demonstrate the application
 - Ethics form needs to be sent to Rob
- Risk analysis needs greater look, Sam going to look through it - Thursday for Rob
- Sam doing costing plan for Tuesday
- Tuesday meeting will involve linking up UML designs, critiquing questionnaires

12/11/2019 Meeting with group

- When meeting with rob draft probably won't include usability
- Reformatting of current report draft
- Usability study - get them done!

14/11/2019 Meeting with Dr. Stewart

- New section: market research
- Adapt requirements to brand research
- Factor in deadlines
- Basic AI / Trees
- Tie in requirements with project specific risks
- Everything on track

26/11/2019 Meeting with group

- Proofing report before submission
 - Checked for consistency
- Peer assessments submitted

14/01/2019 Meeting with group

- Ben doing databases and API
- Front end for Euan with Robert
 - Euan has done login and register template so far, using Vue.js
- Databases and website Adam
- Andrew and Sam doing business website
- Report will be made up of the different parts we are all adding, so we will all handle our own parts of the report
- Looking to have a meeting with Rob in a week, time to catch up on work. 23rd 3:15pm
- Adam looking for javascript library to make a graph
- GitHub has been started, we will be branching the repo, Ben has sent the link to the group chat

21/01/2019 Meeting with group

- Andy doing settings page on website
- Chart.js for adam, for sorting the graphing
- Ben started token authentication, send token with authentication header for API, still working on this
- Euan sorted login and registering, working on responsiveness on dashboard
- Add more user details to registering

23/01/2019 Meeting with Dr. Stewart

- Need to book a room for presenting demo - need somewhere with projector
- Want to refine final requirements to reflect how useful recording all the data is
- Need to specify where the database will live in final deliverable
- Maybe think about recommended settings
- Potentially read about assisted living places and look at safeguards for releases around these places
- Maybe think about prioritising functionality over security
- App ideally would show energy/cost saved
- Energy potentially important feature throughout interfaces
 - Maybe think about peak energy use times?
- Monday 3rd for demo, half 2, Rob is booking room, no meeting with Rob before then