**School of Computer Science and Engineering**

**The University of New South Wales**

# Requirements to Thesis and Project submitted at the School of CSE

by

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## Abstract:

IoT devices improve the quality of everyday life by capturing valuable data to be used for in-depth analytic. With the rapid adoption of innovative and diverse IoT devices, the number devices on-premise will continue to grow. The cost of administrative overhead of these devices become immense without a proper management system.

This thesis aims explore ways to create a single pane of glass to monitor, interact, and rapidly provision IoT devices thus allowing the continual growth in the number of devices without the exponential administration overhead throughout the device lifecycle.

**Keywords:** IoT management, monitoring, Vue Js frontend.

# Abbreviation

**IoT** Internet of things

**ROI** Return on investment

**CSE** Computer, Science and Engineering

**MVP** Minimal variable product

**IT** Industry Technology

**EMIoT** WBS technology IoT management Platform.

**SPA** Smart personal assistant

**RFID** Radio frequency identification

**P&G** Procter and Gamble

**M2M** Machine to machine

**JIT** Just in time

**BI** Business intelligent

**IE** Industrial Edge

**CD/CI** Continuous development and continuous development

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# Chapter 1

# Introduction

The emergence of IoT devices has enabled society to be more connected than ever before, improving the efficiency of daily tasks from scheduling meetings to doing online shopping by performing a single click on a device or just speaking a few words to your IoT personal assistance [3]. The data collected from these devices provide valuable insight in either making critical business decision or assist in making healthier choices.

As the IoT device market matures, devices become more easily accessible and the cost per capita significantly as a result of Moore's law drops making large-scale deployment favourable [11, 47]. Mass deployment growth will halt due to the maintenance, after a device deployed, it is usually forgotten. A device will eventually encounter an issue and require some sort of maintenance. The time spent on maintenance will grow exponentially if not monitored or controlled tightly as devices are spread out across different premises or physical location.

In this project, we will explore IoT challenges faced in commercial environments, and implement additional features on an existing IoT platform to bridge the gaps found in literature review.

This project is in collaboration with WBS technologies in further developing their EMIoT platform to better align with current commercial IoT challenges. WBS technology is an Australian based company which provide all round solution for emergency devices and smart lighting for multi-storey buildings.

The management platform in the solution collect data of the IoT lights and emergence devices to ensure each building is compliance.

# Chapter 2

# Literature Review

## 2.1 Origin of IoT

IoT is defined as any device interconnected to the internet, it comes in many different shapes and forms. The devices have the ability to communicate between each other over a network with or without human intervention. Nowadays, devices are able to connect directly to the cloud and send valuable data for further analysis [27].

The term IoT began with Kevin Ashton in 1999 when he presented the RFID tag proposal to management of P&G [27]. This term did not have an exact meaning until 2008 when it started to trend, and it was an evolution of the concept M2M - machine to machine communication. These devices were responsible for collecting, processing, and sending data to the cloud.

## 2.2 Benefits of IoT

There are many benefits that comes with IoT, these benefits are identified and place into two main groups.

On an individual/consumer level, the IoT devices provide insights and assistance in our daily life with the goal of improving the overall quality of life [29].

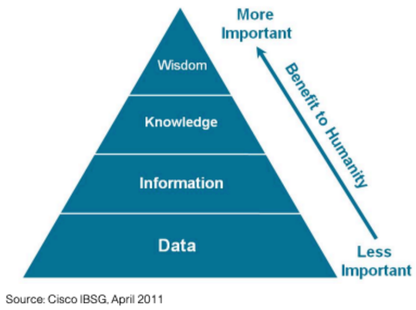



***Figure 2.2:*** *Benefit period from the Cisco IBSG report, April 2011.*

An example of an IoT device is the smart watch which aligns with the pyramid structure above. Popular wearable including the Apple watch and Fitbit helps the user keep track of their health and goals.

Following the pyramid structure above, at the base level, data is collected in real-time and sent to the phone for further processing. On the next levels, processed information is presented to the user so that they can empowered themselves to make better health conscious decision in order to meet their goals. With all the previous accomplishments and failures, the user of the device gains a bit of wisdom about living healthier and knowledge passed onwards to its inner circle [45].

On the enterprise level, instead of the personal goal of gaining better quality of life. An organisation would gain the following [27,22] by adopting the IoT model into their business:

- Progress report on their current strategies.
- Enhance productivity of employees.
- Financial benefits through improved operation methods.
- Rich data collected can allow business to use JIT business model
- Improve customer experience

Some devices which businesses would adopt include floor sensors, thermostats, smart lighting, and personal assistance such as Alexa for business [48].

The floor sensors can monitor supply chain progress in a business and ensures the goods are delivered on time. It can also monitor customer footprint within a cafe and track parts of the day where the business needs to changes its strategy to gain more overall customers.

While smart thermostat and smart lighting can adjust throughout based on a set schedule or adapt due to the external temperature to ensure the best possible experience is provided to the customers.

Alexa for business can schedule office meetings and reminds users of their schedule reducing the administrative overhead thus increasing the efficiency.

With all these benefits on both the individual and organisational level, there are also challenges when deploying on a large scale. These challenges will be discussed later on in the report.

## 2.3 IoT Market Trends

IoT technology is a part of many emerging markets within the last decade alongside big data, cloud computing, and smart technologies. Based on the IDC 2018 forecast, "The IoT market is expected have a compound annual growth rate of 13.7% over the period of 2017-2022 and it is expected spending is to reach $1.2 trillion by the end". Top 3 sector of the market that will contribute to this growth includes consumers, insurance related, and health care [11,36]. As of 2014, the ratio of IoT device to an individual is 1.5 device per person, it is expected to increase to 8 devices by 2020 [44,29].

The Asia region will be the highest adopter of IoT, with India and China increasing application across the varies sectors stated above [49]. IoT has the ability to solve complex problems and its alignment with the Industry 4.0 model will only lead to continuous growth in the next couple of years.

Major players on the market such as Cisco, Google, IBM, Microsoft, and Intel have already heavily invested into the IoT field to provide intent-based networking capabilities to their customer to help accelerate customer IoT projects [49].

## 2.4 Factors to mass IoT Adoption

There are a number of factors which has driven IoT adoption growth in commercial application, the main driven has been identified below.

IoT has the ability to solve complex business problems and enable connectivity between more things. Its characteristic properties perfectly align with the Industry 4.0 initiatives [43]. The Industry 4.0 initiative promotes the of adoption of AI, automation, BI, and M2M to improve workplace safety/productivity, differentiate business, and between connect to supply chain and business.

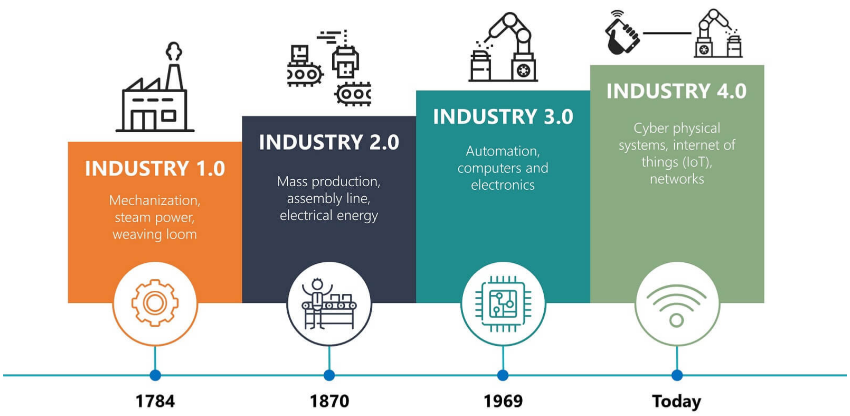



***Figure 2.4:*** *Industry initiative timeline.*

Increase number of transistor count at a decreasing cost in accordance to the Moore's law [47] has increase performance of low power device. The improved manufacturing techniques and outsource to the Asia Pacific region has driven cost of manufacturing down dramatically [11]. With the low manufacturing cost and large supply, followed by Asia's entrance in the ecommerce market, the availability of development Kits and sensors for anyone to begin experimenting has never been that accessible before.

Furthermore, the decreasing cost of 3G and 4G per GB around the world has also contributed to remote deployment, with the average of $2.47 per GB in Australia compared to 10 years ago which was $10 [23]. The forthcoming of 5G technology will further drive IoT adoption as it has low latency and high throughput capabilities will enable business to depend more on Fog computing. Fog computing is an when the edge devices pushing data to the cloud carries out a substantial amount of computing, storage, and communication between local devices [50].

## 2.5 Challenges with IoT Adoption for commercial application

There are many challenges that restrict IoT from being commercially used, according to Gartner's 2014 report, IEEE newsletter and Cisco article [11,37]. Here are the main areas which is of concern for commercial application:

1. Privacy
2. Security
3. Standardisation
4. Automation
5. Visibility
6. Scalability

Traditional consumer based IoT devices has many privacy and security concerns associated to it and these issues are moved to commercial devices as business begin to apply them.
A good example is SPA devices such as Google Nest, and Amazon Alexa [38]. The device takes a set of instructions from a person and performs a task, the task can range from scheduling a meeting, interacting with compatible devices, or even ordering items from Amazon when using Alexa. Despite all these benefits SPA can bring, the default settings of these device pose security and privacy risks. Devices are constantly listening in on conversations and activate once keywords are picked up. The device is typically placed in an open space where other people in proximity can easily activate it as voice authentication is not enforced.

In addition to common issues of devices found by the default settings out of the box, these devices in the past are known to have vulnerability in its WIFI implementation which can be hijacked, and the hijacker can login and escalate the user privilege level taking control over the device. It can even perform a data dump between the device communication to the home Wi-Fi gateway [39-41].

Furthermore, the user data is collected and profiled to create a personalised experience, targeted services are offered in return. With the wealth of data collected the device provider, your is used to establish more business partnership unethically [38].

As the IoT devices move from the consumer space into the enterprise space, a few more challenges arise. The challenges are associated with the ability of these IoT devices to collect data reliably making it a worthwhile deployment.

Both scalability and automation becomes a large driving factor for a business adoption to the IoT model [37], they need the benefit cost ratio to decrease as the devices increases and at the same time they want to reduce the overhead caused by simple repetitive administrative tasks such as updating software, collecting monthly logs, and backup device configurations.

Another challenge with the IoT model is visibility, technical personnel can easily query, analyse problems and schedule maintenance windows for deployed devices. They will understand and leverage one of the many IoT supported protocols such as OPENNMS, SMNP, REST, SOAP, and NETCONF [13,42].

For a less technical personnel, they just need visibility without needing to understand the underlying protocols or be trained in querying devices. A management dashboard is better suited for them in order to perform the same task in maintaining the devices. The management dashboard role will be relaying organised information of devices health and alerting the users of any issues. At the same time, it will have the ability to automate certain actions in terms of a scheduled job.

## 2.6 Current IoT management platform

There are a number of IoT management platforms described in the EY IoT report that fulfil the problems that occur in the IoT field for commercial application. After exploring the different vendors listed on the report, four vendors stood out among the others in terms of their application coverage in commercial IoT. These vendors include IBM Watson, Cisco, AWS, and Azure. [32-35]

Many of the vendors cater to large enterprises and require a subscription or vendor specified hardware to get the platform operational [15-18]. The subscription varies depending on use, with heavy users getting a discount.

**Below is an in-depth analyse of each vendor offering:**

| **Vendor** | **Vendor Hardware requirement** | **Cost model** | **Features** |
|---|---|---|---|
| IBM | No | Per instance Per month | - Connection services<br>- Analytics services |
| Cisco | Yes | Contracted Subscription | - Provides all in one solution |
| AWS | No | Per action plus monthly charges | - Device software<br>- Connectivity and control services<br>- Analytic services |
| Microsoft | No, recommended certified equipment. | Per action plus monthly charges | - Certified dev devices.<br>- Connectivity and control services<br>- Analytic services |

IBM Watson only offers a management dashboard similar to that of Cisco Jasper, information from their product page indicates that they cater toward large enterprise customers. The monthly cost is substantially high compared to both cloud service provider AWS and Azure offerings [32].

Cisco provides a whole package to meet the needs of a commercial customer, from the hardware equipment which is their IE router range to their cloud management platform Jasper. The IE router acts as an edge device to relay the sensors on the premise to the cloud providers, at the same it can host Docker containers to perform light weight compute. Jasper is the management suite which provision, monitors, and automate device jobs [34, 51].

On the other hand, both Microsoft IoT and AWS IoT suite are more transparent with their service offerings, they have examples, and customer use cases in their YouTube videos, and product documentation. Each of these vendor charges based on actions/API calls without a customer having to permanently commit to their solution [16,33,15,18,35]

After exploring the major vendors, there is a trend between each vendor that is they require you to pay an amount before an operational platform can be obtained. A solution will have to build around the vendors supported hardware or method. An IoT project will ends when the vendor decides to stop supporting certain functionality. Furthermore, innovation would be hard due to these barriers.

## 2.7 Problems Statement

There are many challenges which prevent a successful IoT adoption in large scale, here are major problems that currently needs to be addressed to enable the IoT model for a business.

1. Automation
2. Scalability
3. Visibility

The other challenges will improve over time as businesses begin to conform with the IEEE standards and technology improves alongside new government policies to address the two other issues- security and privacy.

## 2.9 Aims and outcomes

This thesis aims to explores ways to overcomes the restrictions that comes along with the IoT model. The motivation behind taking on this project aims to create IoT management efficiency and create a unified tool for management.

**The main objective of this IoT frontend:**

1. Monitor and visualise device data.
2. Provide different view set for different user groups.
3. Develop automated method to group and sort devices into their respective group during onboarding.

# Chapter 3

# Methods

## 3.1 Software development approach

Every software project has a development lifecycle, the lifecycle begins with the definition of the specification, prototyping, testing, delivery and the patches to maintain the software product. Two commonly used software development methodology are agile and waterfall method [52].

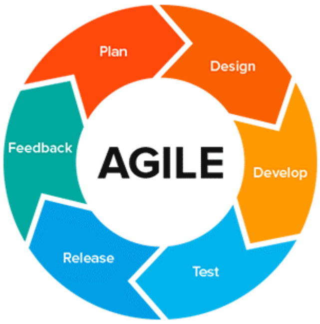



***Diagram 3.10:*** *Flowchart of agile*

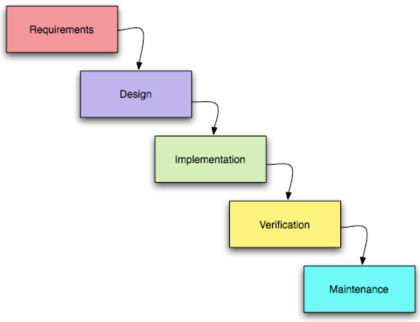



***Figure 3.11:*** *Flowchart of Waterfall.*

IoT frontend development will adopt agile development approach, the method aims to rapidly develop features, align with customer specification, and high-quality product. The new IoT frontend will be developed in parallel with the production system, the aim is to implement new features while mimicking the current stack as close as possible to ease future integrations [9]. The waterfall approach would not be able to accommodate the current situation as the product is already in production.

The CI/CD is a practice is commonly employed by many developers to continuously develop new features at the same time build and integrate them into the production environment. The process is fully automated pipeline and there is no need for human intervention hence cutting down possible errors and time taken to push changes [53].

Below is an environment that is planned to be used during the development, both GitHub and docker has already been setup. The reason behind using this architecture is to prevent human error from occurring especially during the docker build stage.

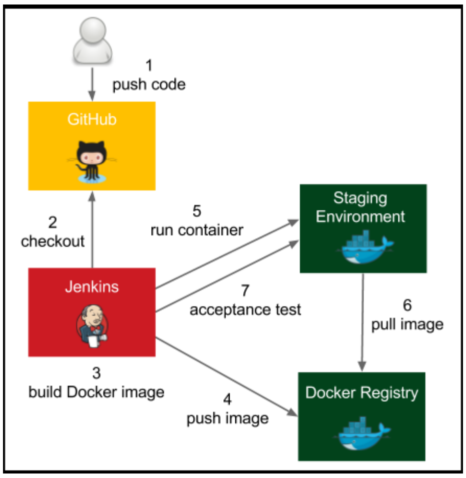



***Figure 3.12:*** *CD/CI architecture.*

Source: medium

## 3.2 Design techniques

The frontend will follow the commonly adopted principle in UX design, the Schneiderman's Eight Golden Rule. The project strives to meet at least 5 of the 8 rules proposed by the design principle [2].

Below are the 5 rules the project wishes to accomplish and its respected method on obtaining competency.

| **Rule** | **Method** | **Targeted Feature** |
|---|---|---|
| Strive for consistency | A templated layout/theme for all views. | All views. |
| Shortcuts | Showing simplified information when hover over devices, and grouping devices based on type on the dashboard. | Dashboard and Map view. |
| Design Dialogs to yield | Creating an intuitive frontend which match the navigation flow of similar management platforms. | All views. |
| Easy reversal of action | Providing save and cancel button for user position devices on the map.<br><br>Undo button to reverse the last action in the import and map drawing functionality. | Map and custom map creation view. |
| Simple error handling | Displaying messages such as "not found", and complaining about missing information, and dialog next to areas where the | Search bar, category creation, and map view. |

| | | |
|---|---|---|
| | information is entered incorrectly. | |

Other design technique that will be adopted is modular programming, the concept is a software design technique which enforces function in a program should be independent of another, and if modules are interchanged, the program should still be functional [53].

The goal is to easily maintain the code base, swapping modules would not comprise other functionality. The migration of certain features to the EMIoT stack would become effortless as it made in this fashion once the feature has been accepted by WBS technology.

## 3.3 Evaluation techniques

Quantitively analyse will be performed after the MVP delivery date. A guided Google survey will be sent out to peers, current user and colleagues. The survey will consist of a user story to simulate the user perspective followed by links to certain views of the site, answering a small set of question which evaluate the current design, functionality, and feature.

**Every view will have the following questions:**

1. Here we have the dashboard of vendor X, now compared to this dashboard. Please give a rating on navigation, ease of use, and information clarity.

2. From your experience, think of one program that you enjoy using and had a similar view. Please comment and link below.

3. What do you think was missing? How can we improve? Leave a comment.

## 3.4 User stories

After discussing with the supervisor and the product owner EMIoT, here are the user stories and mapping to their respected features. The user stories have been divided into the user groups and some user stories overlap so they are place into the general group.

### Network Admins

| # | User Stories | Features |
|---|---|---|
| **1** | As a network administrator, I want to take a quick peek of the device status so I can obtain more information about the device and troubleshoot further. | Tooltip on device status and summarised for network admins. |
| **2** | As a network administrator, I want a dashboard to see a summary of all the device health on my home page so I can be assured that nothing is broken and reduce the time in trouble by click on the errors. | Dashboard view for network admins. |
| **3** | As a network administrator, I want to see a detailed report of a device so I can ensure that the device is deployed correctly and if any changes will need to be made to it. | Individual device detail information view for network admins. |

## Strata managers

| # | User Stories | User Stories |
|---|---|---|
| **4** | As a strata manager, I want to hover over a device icon on the map and see the status of it so I can see recent problems, perform quick audit and better plan for maintenance. | Tooltip on device status, and summarised for network admin. |
| **5** | As a strata manager, I want to click on the device icon and get a detail page of the device so I can check if the device information is correctly recorded and look at past events and make management decision to prevent future occurrences i.e. deploy a pair of devices and run it in HA. | Individual device detail information view for strata managers. |
| **6** | As a strata manager, I want to see an overall health of all the device in my home page, so I know if I am compliant and understand what needs to be fixed. | Dashboard view for strata managers. |
| **7** | As a strata manager, I want a side and top view for the device map so I can see a summary of devices per floor and a more detail map of devices deploy on that particular floor. | Map top view and side view for strata managers. |

## Other users

| # | Contractors | User Stories | User Stories |
|---|---|---|---|
| **8** | | As a contractor, I want to be able to locate the broken device through a map and repair it, so I do not have to waste my time looking around for the device especially if I am new to this building. | Reduced map view for contractors (basic information such as name and location). |
| | **Owner** | | |
| **9** | | As an owner, I want the users to see the only necessary information required to do their job, so I can ensure the management tool is effective in monitoring deployed devices and protect other information from being seen by unauthorised users. | Login page and view restriction based on user group. |

## All users

| # | User Stories | User Stories |
|---|---|---|
| **10** | As a user, I want to be able to quickly find my device by typing in the name or ID so I can gather information quickly and perform my assigned task. | Search bar. |
| **11** | As a user, I want to click on a category of devices and see all the devices associated category, so I perform an audit, repair, or troubleshoot depending on my role. | Device tag and category tab on the nav bar. |

| | | |
|---|---|---|
| **12** | As a user, I want to be able to know which type of device it is by looking at the icon on the map so I do not have to click on the device and go to the detailed information page to figure out what type of device it is. | Device icons based on device type. |
| **13** | As a user, I want to get the status of deployed devices on a map by looking at the colour of the pin, so I know which device I have to look further into and perform the relevant task depending to make it healthy again. | Device status pins. |
| **14** | As a user, I want to navigate through the different floors without having to reload the page so I can find the device quick and navigate around the building faster. | Floor nav bar on the map. |

## 3.5 Mock-ups

**Dashboard view**

The dashboard view shows overview of device deployed on a current site, for an administrator he/she will see all the network analytics. For the strata management, the information would be only the health of the device and if the building is compliant.

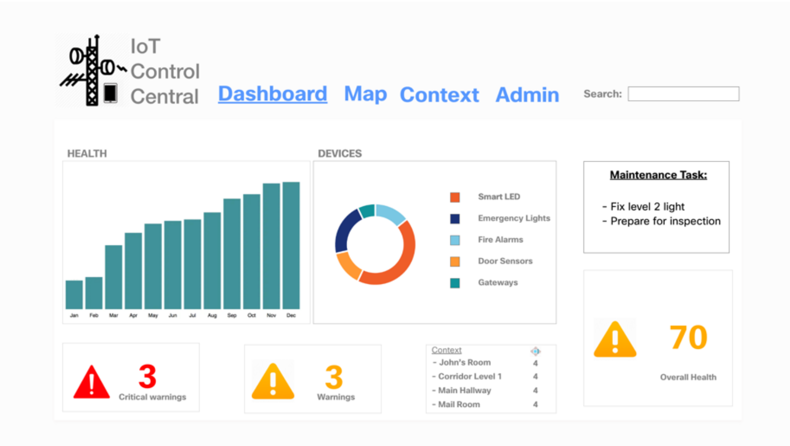



***Figure 3.50:*** *Mock showing features: 6, 4 (Strata manager view)*

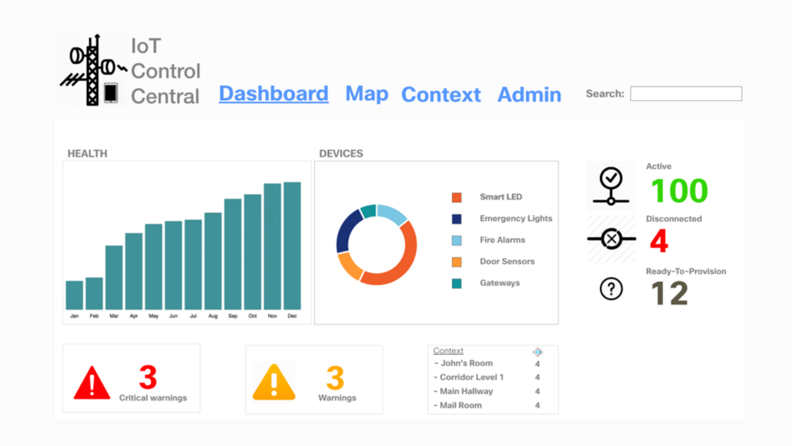



***Figure 3.51:*** *Mock showing feature: 2 (Network administrators view)*

### Context view

The context view is an organised view for devices where users can tag devices and put them into a folder. It promotes easy access for user next time so that they do not have to search device by ID, mac address, or navigate through countless map views.

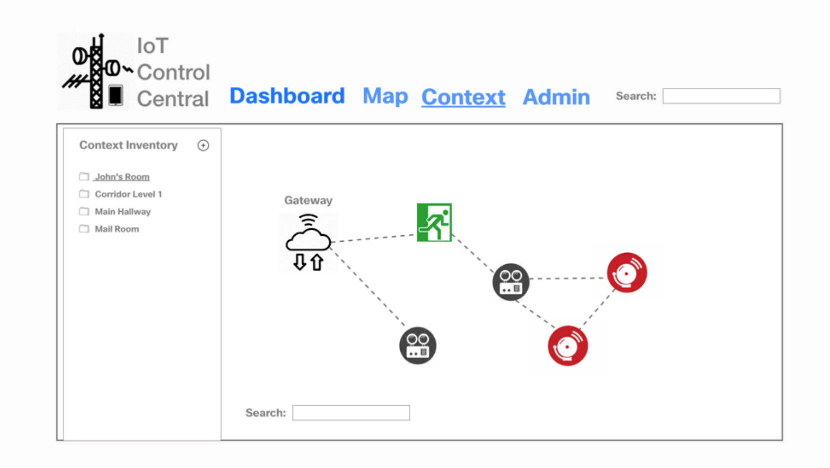



***Figure 3.52:*** *Mock showing features: 10,11 (for all users except contractors)*

### Detailed device view

The detailed device view display shows the current status of a device in detail and provide other historical data. The view is primarily used to troubleshoot the device and to gain an insight of the device. The view varies between network administrator, strata managers, and contractors.

The strata manager would only see device name, model, historical data, and faults below whereas contractors would only see name, model, and location.

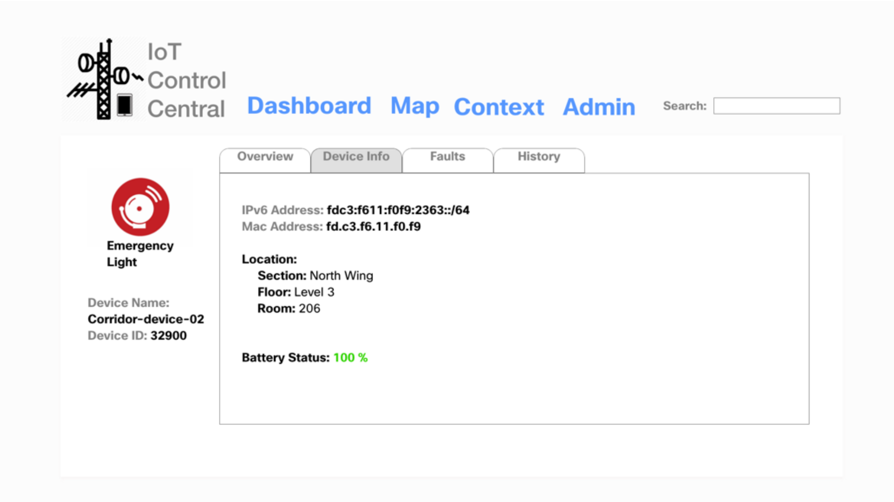



***Figure 3.53***: *Mock showing features: 3, 5, 10*

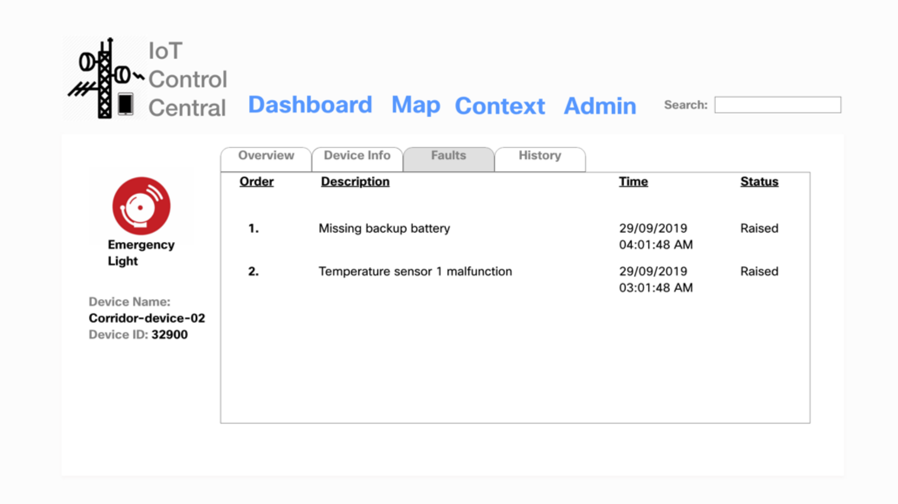



***Figure 3.54***: *Mock showing features: 3, 5, 10*

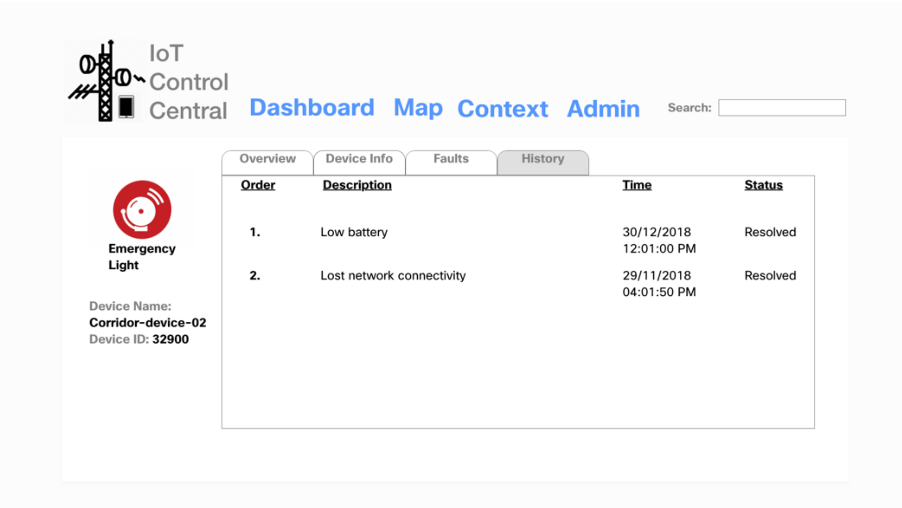



***Figure 3.55***: *Mock showing features: 3, 5, 10*

**Floor plan map view**

The floor plan view provides a graphic interface of the site, when hovering over the pinpoints will display a brief snippet of information about the device. When the user clicks on the top right corner, he/she may edit the device location. The buttons in center left of the iframe allows the user to toggle between top view and side view. The top view is shown below, while the side view will be showing a summary of the device on that particular floor. The numbered icon is allowing the user to navigate between each floor. Contractors will be restricted to editing device location on the map and strata managers would not see the topology view tab.

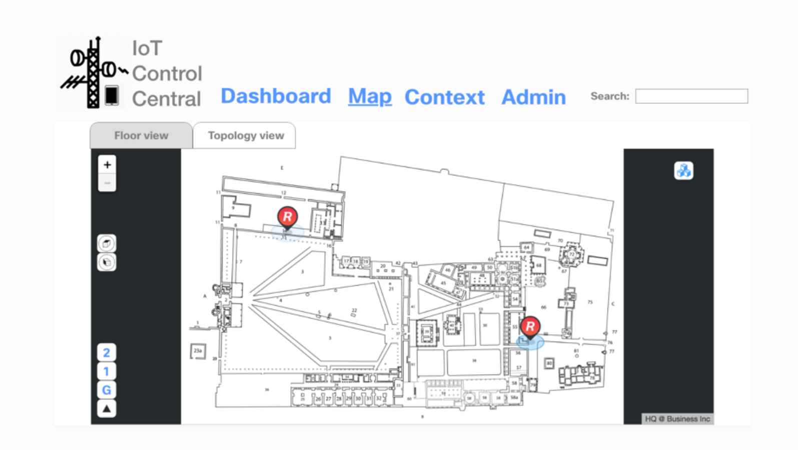



***Figure 3.56***: *Mock showing features: 1, 7, 8, 10, 12, 13, 14*

An addition feature to the map for network administrator view is the topology view, where he/she can click on this tab to see the gateway of that particular floor and all the device connected to it, it enable ease of troubleshooting.

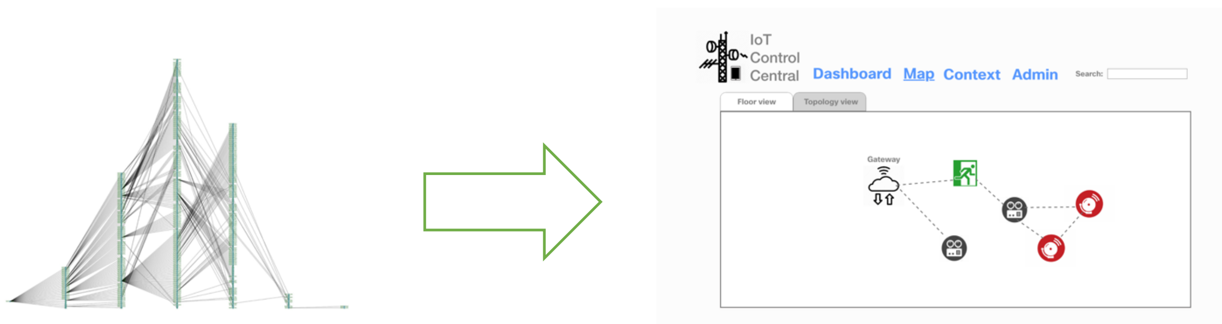



***Figure 3.57***: *Mock showing feature: 10, 13*

## 3.6 Technology selection criterion

The technology selection criteria are based on a number of factors. Here are the main factors that was accounted when the technology was picked:

1. Compatibility of the technology when ported over to the partner environment
2. Current trends
3. Community support and sample code
4. Existing stack already deployed by partner
5. Stable releases

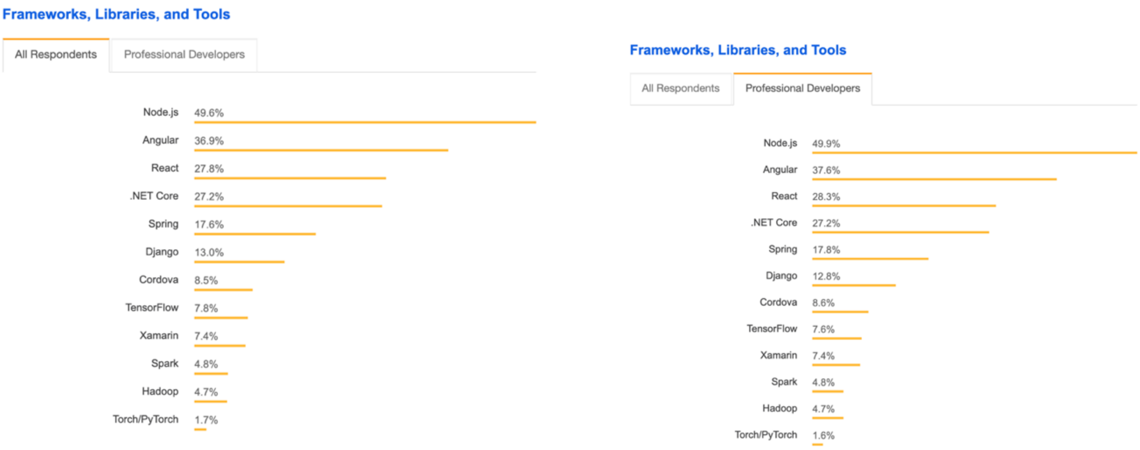



**Figure 3.7**: *Stack Overflow developer survey result for 2018.*

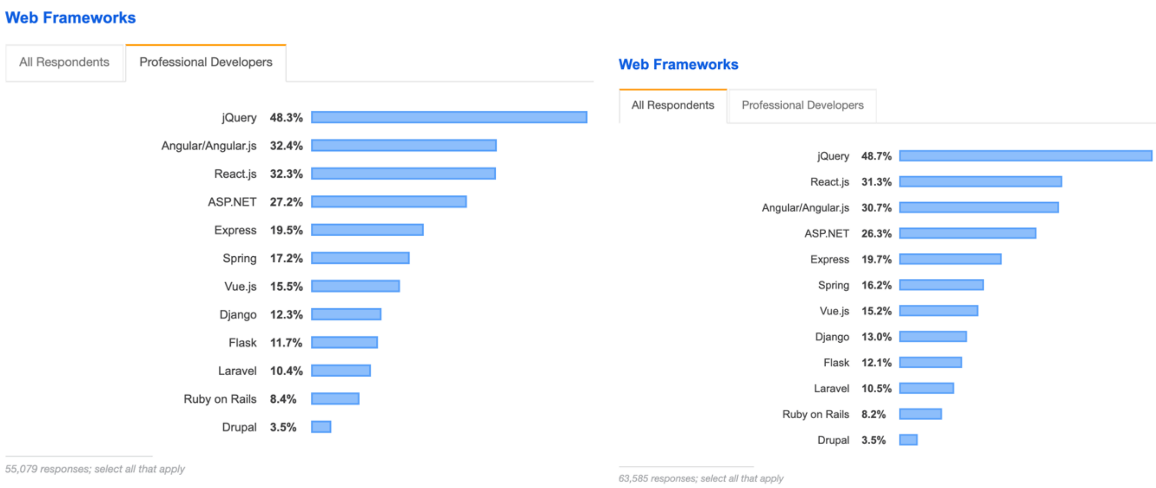
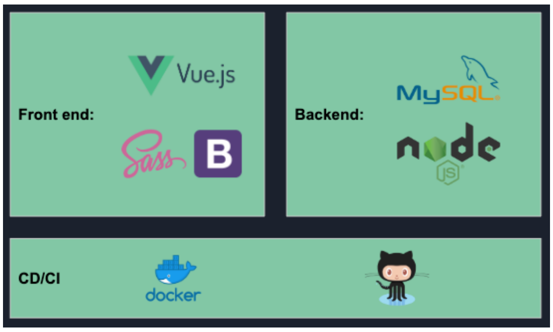



**Figure 3.8:** *Stack Overflow developer survey result for 2019.*



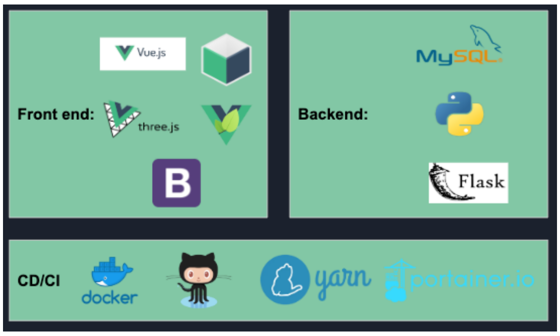




***Figure 3.81:*** *Current production stack of EMIoT*

***Figure 3.82:*** *Proposed stack*

For this project, the backend chosen is Python3 and Flask, due to its versatility and ability to connect to cloud services if needed and additional data processing. Similarly, Flask will be used as to API end point for Python to communicate with the frontend.

For the frontend, the project will retain most of the production stack employed by EMIoT as we wish to port certain features over with a few additional JavaScript libraries to enable features such as the map and dashboard views.

**The addition libraries include:**

- Three JS (optional web-based animation library)
- Leaflet Js (Creating map frames for the map view)
- Vue Chart Js (Native view graph library to create charts and graphs for the dashboard view).

Furthermore, additional CI/CD tools will be used to manage the project, these include Yarn for dependency management and Portainer for command line errors.

## 3.7 System architecture

A commonly rapid development CRUD stack will be used to develop the IoT frontend, alongside commonly used graphing and graphical libraries to enable transition to future development teams. Each component of the frontend will be discussed in detail later, the aim is to develop an application that is reusable, flexible, modular, cross platform compatible, and easily supported.

| | |
|---|---|
| **Web Framework** | Vue JS |
| **CSS/theme** | Vue native bootstrap |
| **Python Web Template Framework** | Flask |
| **Middleware** | Python 3 |
| **Python Libraries** | NumPy |
| **2D graph library** | Vue Chart Js |
| **Software library management tool** | YARN |
| **Software virtualisation + integration (optional)** | Docker + Docker compose |
| **Local cache database (optional)** | Couch DB or MongoDB |
| **3D Animation (option)** | ThreeJS |
| **2D Map library** | Leaflet Js |

***Diagram 3.10:*** *The stack technology*

## Component Roles

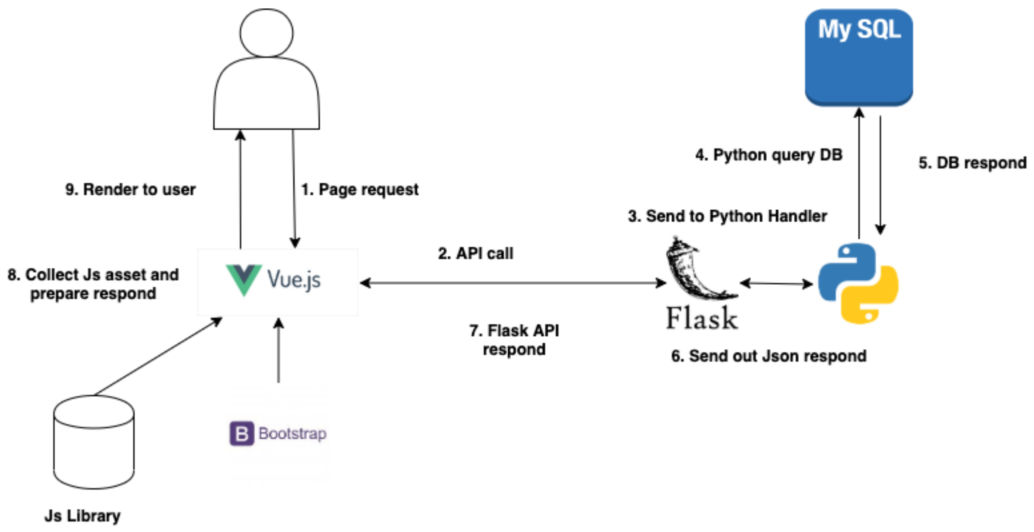



***Diagram 3.11:*** *Architecture overview.*

**Frontend**

Vue Js would be responsible for routing users to the different views as described in the user stories and mock-up. The project will adopt the Multiview component model where every page is built on different individual component for the stake of portability in the future. Vue Js will call the Python rest API backend and relay all information to its counterparts to render the dashboards, and maps.

The CSS will be handled by bootstrap to reduce the design overhead and avoid the use of custom schemes. Bootstrap is tested between releases and is compatible with various browsers compared to custom schema that can possibly break with a new update of the frontend application.

**Backend**

Python is responsible querying the MySQL database and parsing it to conform with the API output. An API will be created with Flask which can be called by the Vue to get the information required.

The NumPy python library is heavily optimised to parse and organise large dataset. In the case that the database is down, or extra data is needed from the device, NumPy will be able to handle the workload as the performance is closely matched to algorithms written in C++.

YARN is an alternative dependency management tool to NPM, it is more stable and easier to use. Compared to NPM, when large amount of dependencies is being pulled the runtime is quicker. The build time will be faster as they grow with new dependencies introduced to the stack.

When the stack moves into the production phase, containerisation of the stack will allow abstraction of the complicated internal workings to the deployment users. By putting the stack into a container, the dependencies strict requirement will be fulfilled, and the expected behaviour is reproducible on any platform. Docker images can be placed into a Kubernetes cluster or into a Docker swarm cluster. The frontend automatically deployed and orchestrated depending on user demand.

## 3.8 Library exploration

Below is the exploration of the libraries stated above and code snippet demonstrate that these libraries tie into the use cases:

| **Library** | **Use Case** | **Examples** |
|---|---|---|
| ThreeJS (optional) | Show the interaction of IoT devices with gateway or other devices via 3d animation. | https://threejs.org/examples/?q=map#webgl_animation_keyframes https://codesandbox.io/s/0pp3x92n4p |
| Leaflet JS | Interactive maps 2D and 3D floor plans. | https://codepen.io/zachdunn/pen/VvRXdP |
| Vue charts | Create an interactive frontend dashboard with rich charts and graphs to display the overall health of the deployment. | https://codepen.io/SitePoint/pen/eENvmV |

## 3.9 Project risk management

A majority of IT projects in industry has delivered late, overbudget, and minimum function delivered than it has promised [20] leading to spiral of problems eventually, the project fails. Every project has risk attached to it, it is important to identify the risk early on the project cycle and map to them to possible resolutions [21].

There are different types of risk associated with software development, the

| **Risk Factor** | **Control Factor** | **Types of Risk** | **Identified Possible Risk** |
|---|---|---|---|
| Moderate | Moderate | Development Environment Risk | Overwhelmed by other commitment. |
| Moderate | High | Process Issue Risk | CI/CD configuration or stack may be broken between builds. |
| Moderate | High | Staff Size and Experience Risk | Some libraries used may have steep learning curves. |
| Moderate | High | Schedule Risk | Core functionality sprints maybe extended and overlap with other sprints. |
| High | High | Technical Issue Risk | n/a |
| High | High | Technology Risk | Current libraries employed may not be sufficient to develop all the features or have compatibility issues. |

A number of ways can be employed to overcome the risk and reduce the impact of it on the project. Here are some of the methods which includes:

- Use rule of thumb, addressing high risk problem early.
- Being transparent about progress and problems with supervisor.
- Setting calendar remainders and adopt a management tool – pivot tracker.

# Chapter 4

# Planning & Scheduling

## 4.1 Planning & Scheduling

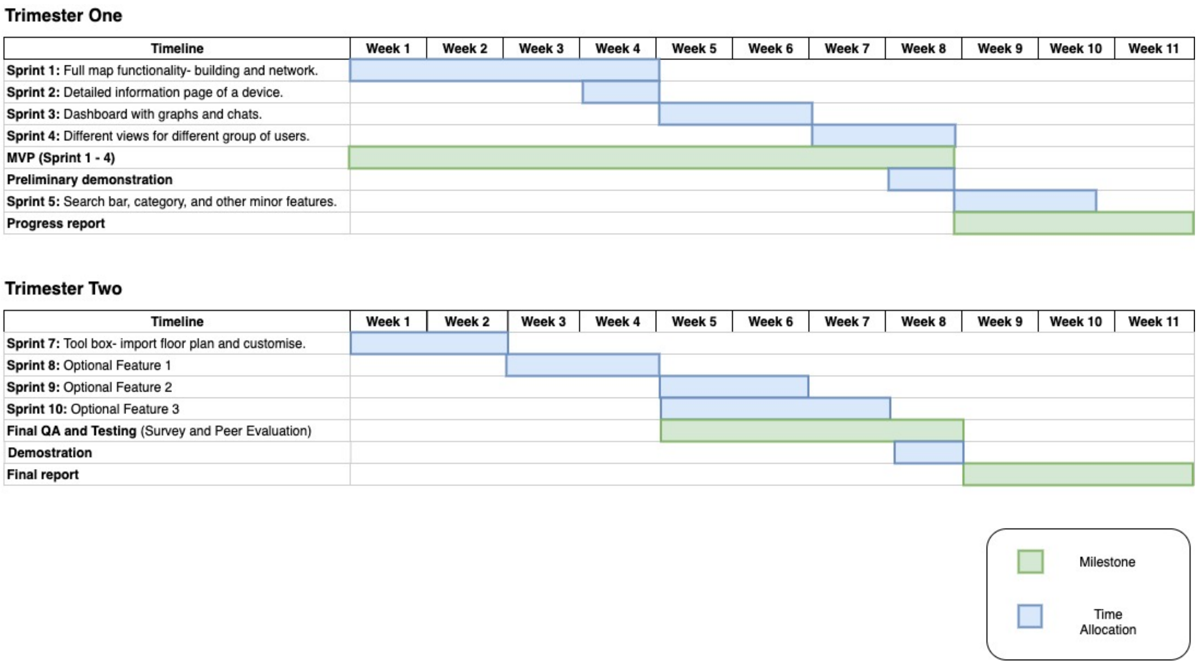



***Figure 4.1:*** *Plan schedule of the Thesis B and Thesis C.*

The allocation and the ranking of each task from the table above is done from the following aspect:

- **Weight**: higher value features get more time allocated to it.
- **Feature dependency**: dependent features will need to be developed first.
- **Reasonable timeframe**: accounting to possible problems and reserve a buffer to correct the issue.

Trimester 2 aim is to deliver the minimum variable product for the project. would be a frontend sufficient enough to be deployed and show to customers or peers to enable feedback to be collect [31]. The feedback would be studied to see the product current state ability and see if it has solved the issues as discussed in the aim of this Thesis.

Most of the core functionality is placed into the MVP as the aim is to deliver something that would maximise depth of the respond when a short survey is performed in progress report of that Trimester 2.

In Trimester 3, the main focus of the project is to refine the features after studying the feedback from the survey and develop addition features.

Here is a list of addition features planned:

- Navigation system for contractors to help them get around the building.
- Toolbox view import floor plans and customise the map view.
- Guest account feature to add new service contractors on the fly.

## 4.2 Tools

With any software development, tools can significantly ensure that the project is managed well and consistent throughout the deployment. Furthermore, it can help assist in keeping track of deployment ensuring that deadlines are met, track bugs and anomalies and testing the interface. Below are the tools that will be used:

**Selenium**

Selenium is an open automated UI testing tools developed to reduce the workload in repetitive inefficient manual testing [36]. There are four different tools in the suite, in the project only the WebDriver and Selenium grid will be employed to ensure the build in between sprint still conforms with previous specifics.

**Pivot Tracker**

Pivot tracker is agile software development management tool which helps keep track of the progress of the project [37].

## 4.3 Preliminary Work

Here is the progress so far with this project:

- Setup development environment on the VM.
- Deployed database provided by WBS Technologies to a Docker VM.
- Query the database and recorded query statements that will be used by the Python backend to write the API.

## 4.4 Future work

Here is a listed of jobs that needs to be done in the future:

- Create the Python API endpoint.
- Deploy and setup Jenkins on the VM.
- Write Jenkins script to start the pipeline.
- Begin the sprint.

## Conclusion

IoT devices brings a wealth of benefits, on the commercial level, IoT devices enhances business operations by giving business real-time insight in their daily operations and giving them a competitive edge and enabling Industry 4.0. Currently research has identified three major problems that has halted the commercial adoption of IoT. They are Automation, Scalability, and Visibility. These issues are interrelated with management processes and can be overcome through the implementing an IoT frontend. Furthermore, by meeting the objectives stated in aims and outcome, these issues will be resolved. Future work will leverage the existing EMIoT platform to create addition functionality to better tackle these issues.

## Bibliography

[1] A. Banafa, “Three Major Challenges Facing IOT,” IEEE Internet of Things, March 2017. [Online]. Available: https://iot.ieee.org/newsletter/march-2017/three-major-challenges-facing-iot.html. [Accessed 3 November 2019].

[2] E. Wong, “Shneiderman’s Eight Golden Rules Will Help You Design Better Interfaces,” Interaction Design Foundation, November 2019. [Online]. Available: https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces. [Accessed 9 November 2019].

[3] IEEE Innovation at Work, “6 Ways You’ll Directly Benefit from the Internet of Things,” IEEE Innovation at Work, [Online]. Available: https://innovationatwork.ieee.org/6-iot-benefits. [Accessed 9 November 2019].

[4] “UNSW heralds in the era of talking buildings,” Architecture & Design, 11 December 2018. [Online]. Available: https://www.architectureanddesign.com.au/news/unsw-heralds-in-the-era-of-talking-buildings?from=timeline&isappinstalled=0#. [Accessed 11 November 2019].

[5] E. Wohlgethan, “Supporting Web Development Decisions by Comparing Three Major JavaScript Frameworks: Angular, React and Vue.js,” 2018. [Online]. Available: http://edoc.sub.uni-hamburg.de/haw/volltexte/2018/4350/pdf/BA_Wohlgethan_2176410.pdf. [Accessed 10 November].

[6] “Developer Survey Results 2018,” Stack Overflow, 2018. [Online]. Available: https://insights.stackoverflow.com/survey/2018. [Accessed 11 November 2019].

[7] J. Horváth, “Vue.js,” 18 February 2019. [Online]. Available: https://homel.vsb.cz/~hor0282/it/hor0282_IT.pdf. [Accessed 11 November 2019].

[8]“Developer Survey Results 2019,” 2019. [Online]. Available: https://insights.stackoverflow.com/survey/2019. [Accessed 11 November 2019].

[9] "Agile Manifesto," 2001. [Online]. Available: https://agilemanifesto.org/iso/en/manifesto.html. [Accessed 12 November 2019].

[10] A. Banafa, "IoT and Blockchain Convergence: Benefits and Challenges," 10 January 2017. [Online]. Available: https://iot.ieee.org/newsletter/january-2017/iot-and-blockchain-convergence-benefits-and-challenges.html. [Accessed 2012 November 2019].

[11] R. Rishi and R. Saluja, "Future Of IoT," Ernest & Young, 2019. [Online]. Available: https://www.ey.com/Publication/vwLUAssets/EY_-_Future_of_IoT/$FILE/EY-future-of-lot.pdf. [Accessed 12 November 2019].

[12] I. Lee and K. Lee, "The Internet of Things (IoT): Applications, investments, and challenges for enterprises," July-August 2015. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0007681315000373. [Accessed 12 November 2019].

[13] J. d. C. Silva, J. J. P. C. Rodrigues, J. Al-Muhtadi, R. A. L. Rabêlo and V. Furtado, "Management Platforms and Protocols for Internet of Things: A Survey," US National Library of Medicine National Institutes of Health, 7 February 2019. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6387169/. [Accessed 12 November 2019].

[14] L. Columbus, "2018 Roundup Of Internet Of Things Forecasts And Market Estimates," Forbes, 13 December 2018. [Online]. Available: https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#17ad859e7d83. [Accessed 12 November 2019].

[15]A. Kiggins, "Manage IoT Devices throughout Their Lifecycle - AWS Online Tech Talks," AWS Online Tech Talks, 18 February 2018. [Online]. Available: https://www.youtube.com/watch?v=8xsuOw0jw00. [Accessed 12 November 2019].

[16] "Azure IoT Central intro walkthrough," Microsoft Developer, 18 February 2018. [Online]. Available: https://www.youtube.com/watch?v=G32stXSwtyA. [Accessed 12 November 2019].

[17] "Control Center Product Tour - 3: Cost management," CISCO IoT, 12 September 2017. [Online]. Available: https://www.youtube.com/watch?v=nVJWWlVOSUg. [Accessed 13 November 2019].

[18] "AWS re:Invent 2018: Managing Devices at Scale with AWS IoT Device Management, ft. Hudl (IOT207-R)," 3 December 2018. [Online]. Available: https://www.youtube.com/watch?v=DxRfsPTwdkc. [Accessed 13 November 2019].

[19] M. Keil, R. C. Schmidt, K. Lyytinen and . P. E. Cule, "A Framework for Identifying Software Project Risks," ACM, November 1998. [Online]. Available: https://www.researchgate.net/profile/Kalle_Lyytinen/publication/220426227_A_Framework_for_Identifying_Software_Project_Risks/links/00b7d517ae608e7ba4000000/A-Framework-for-Identifying-Software-Project-Risks.pdf. [Accessed 12 November 2019].

[20] A. K. Rai, S. Agrawal and M. Khaliq, "Identification of Agile Software Risk Indicators and Evaluation of Agile Software Development Project Risk Occurrence Probability," 2017.

http://www.ijetmas.com/admin/resources/project/paper/f201707171500305657.pdf

[21] M. Keil and L. Wallace, "Software Project Risks and Their Effect on Outcome," ACM, 2004.

http://www3.cis.gsu.edu/dtruex/courses/MBA8125/Articles/WallaceKeil-Project%20Risk%20and%20Outcomes-CACM%202004.pdf

[22]

M. F. A. Zaidi, "The IoT Readiness of SMEs in Malaysia: Are they Worthwhile for Investigation?," in *International Conference on International Business, Marketing and Humanities*, Malaysia, 2017.

https://www.researchgate.net/publication/319311693_The_IoT_Readiness_of_SMEs_in_Malaysia_Are_they_Worthwhile_for_Investigation

[23] N. McCarthy, "The Cost Of Mobile Internet Around The World," Forbes, 5 March 2019. [Online]. Available: https://www.forbes.com/sites/niallmccarthy/2019/03/05/the-cost-of-mobile-internet-around-the-world-infographic/#4e95f872226e. [Accessed 14 November 2019].

[24] C. Lindley, "Front-End. Developer Handbook 2019," Frontend Masters, 20 August 2019. [Online]. Available: https://github.com/FrontendMasters/front-end-handbook-2019. [Accessed 14 November 2019].

[25] R. Minerva, A. Biru and D. Rotondi, "IEEE Towards a Definition of Internet of Things (IoT)," IEEE Internet of Things, 13 May 2015. [Online]. Available: https://iot.ieee.org/images/files/pdf/IEEE_IoT_Towards_Definition_Internet_of_Things_Issue1_14MAY15.pdf. [Accessed 14 November 2019].

[26] J. E. Ibarra-Esquer, F. F. González-Navarro, B. L. Flores-Rios, . L. Burtseva and M. A. Astorga-Vargas, "Tracking the Evolution of the Internet of Things Concept Across Different Application Domains," Sensors (Basel), 14 June 2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5492403/. [Accessed 14 November 2019].

[27] M. Rouse, L. Rosencrance, S. Shea and I. Wigmore, "Guide to Cloud Application Testing - Internet of Things (IoT)," IoT Agenda, July 2019. [Online]. Available: https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT. [Accessed 14 November 2019].

[28] F. Mattern and C. Floerkemeier, "From the Internet of Computers to the Internet of Things," [Online]. Available: http://www.vs.inf.ethz.ch/publ/papers/Internet-of-things.pdf. [Accessed 14 November 2019].

[29] D. Evans, "The Internet of Things - How the Next Evolution of the Internet is Changing Everything," CISCO, April 2011. [Online]. Available:

https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf. [Accessed 15 November 2019].

[30] J. E. Ibarra-Esquer, F. F. González-Navarro, B. L. Flores-Rios, . L. Burtseva and M. A. Astorga-Vargas, "Tracking the Evolution of the Internet of Things Concept Across Different Application Domains," Sensors (Basel), 14 June 2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5492403/. [Accessed 14 November 2019].

[31] "Minimum Viable Product (MVP)," Agile Alliance, [Online]. Available: https://www.agilealliance.org/glossary/mvp/#q=~(infinite~false~filters~(tags~(~'mvp))~searchTerm~'~sort~false~sortDirection~'asc~page~1). [Accessed 15 November 2019].

[32]
"IBM Watson IoT Platform," IBM, [Online]. Available: https://www.ibm.com/au-en/marketplace/internet-of-things-cloud. [Accessed 15 November 2019].

[33] "Microsoft Azure - Internet of Things (IoT)," Microsoft, [Online]. Available: https://azure.microsoft.com/en-au/product-categories/iot/. [Accessed 15 November 2019].

[34]
"Manage Connectivity of All Your IoT Devices," CISCO Jasper, [Online]. Available: https://www.jasper.com/. [Accessed 15 November 2019].

[35]
"AWS IoT," Amazon Web Services, [Online]. Available: https://aws.amazon.com/iot/. [Accessed 15 November 2019].

[36] L. Columbus, "2018 Roundup Of Internet Of Things Forecasts And Market Estimates," Forbes, 13 December 2018. [Online]. Available: https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#5b0845cc7d83. [Accessed 15 November 2019].

[37] C. Byers, “Challenges in real-world edge computing architecture,” CISCO, 16 November 2018. [Online]. Available: https://www.cisco.com/c/en/us/solutions/internet-of-things/iot-edge-computing-architecture.html. [Accessed 15 November 2019].

[38]
J. S. Edu, J. M. Such and G. Suarez-Tangil, “Smart Home Personal Assistants: A Security and Privacy Review,” 19 March 2019. [Online]. Available: https://arxiv.org/pdf/1903.05593.pdf. [Accessed 16 November 2019].

[39] NortonLifeLock, “Can Smart Speakers be Hacked? 10 Tips to Help Stay Secure,” Norton, 2019. [Online]. Available: https://us.norton.com/internetsecurity-iot-can-smart-speakers-be-hacked.html. [Accessed 16 November 2019].

[40]
M. Cermak, “What was wrong with Alexa? How Amazon Echo and Kindle got KRACKed,” ESET, 17 October 2019. [Online]. Available: https://www.welivesecurity.com/2019/10/17/alexa-how-amazon-echo-kindle-got-kracked/. [Accessed 16 November 2019].

[41] T. Spring, “DEF CON 2019: Researchers Demo Hacking Google Home for RCE,” Threat Post, 9 August 2019. [Online]. Available: https://threatpost.com/def-con-2019-hacking-google-home/147170/. [Accessed 18 November 2019].

[42]“IoT Standards and Protocols,” Postscapes, [Online]. Available: https://www.postscapes.com/internet-of-things-protocols/. [Accessed 18 November 2019].

[43] Department of Industry, Innovation and Science, “Industry 4.0,” Australian Government, November 2019. [Online]. Available: https://www.industry.gov.au/funding-and-incentives/industry-40. [Accessed 20 November 2019].

[44] “What is the Internet of Things? And why should you care? | Benson Hougland | TEDxTemecula,” TEDx Talks, 17 December 2014. [Online]. Available:

https://www.youtube.com/watch?v=_AlcRoqS65E&feature=emb_title. [Accessed 20 November 2019].

[45] D. Metcalf, S. T. Milliard, M. Gomez and M. Schwartz, "Wearables and the Internet of Things for Health: Wearable, Interconnected Devices Promise More Efficient and Comprehensive Health Care," *IEEE,* vol. 7, no. 5.

[46] J. Parsons, "8 Ways IoT Devices Can Improve Your Business Office," Entrepreneur Asia Pacific, 3 September 2019. [Online]. Available: https://www.entrepreneur.com/article/338499. [Accessed 21 November 2019].

[47]
K. Flamm, "Measuring Moore's Law: Evidence from Price, Cost and Quality Indexes," National Bureau of Economic Research, April 2018. [Online]. Available: https://www.nber.org/papers/w24553.pdf. [Accessed 22 November 2019].

[48]
J. Parsons, "8 Ways IoT Devices Can Improve Your Business Office," Entrepreneur Asia Pacific, 3 September 2019. [Online]. Available: https://www.entrepreneur.com/article/338499. [Accessed 21 November 2019].

[49] "Internet of Things (IoT) Market - Growth, Trends and Forecast (2019 - 2024)," Mordor Intelligence, 2019. [Online]. Available: https://www.mordorintelligence.com/industry-reports/internet-of-things-moving-towards-a-smarter-tomorrow-market-industry. [Accessed 21 November 2019].

[50] B. Butler, "What is fog computing? Connecting the cloud to things," Network World from IDG, 17 January 2018. [Online]. Available: https://www.networkworld.com/article/3243111/what-is-fog-computing-connecting-the-cloud-to-things.html. [Accessed 22 November 2019].

[51] “IoT Routers,” CISCO Systems, [Online]. Available: https://www.cisco.com/c/en/us/solutions/internet-of-things/iot-routers.html. [Accessed 22 November 2019].

[52]
I. Korkishko, “Top 6 software development methodologies,” DEV, 11 October 2017. [Online]. Available: https://dev.to/iriskatastic/top-6-software-development-methodologies-9b. [Accessed 22 November 2019].

[53]
S. Pittet, “Continuous integration vs. continuous delivery vs. continuous deployment,” Atlassian CI/CD, 2019. [Online]. Available: https://www.atlassian.com/continuous-delivery/principles/continuous-integration-vs-delivery-vs-deployment. [Accessed 23 November 2019].

[54] M. Xu, “Single page apps in depth,” 28 September 2017. [Online]. Available: http://singlepageappbook.com/index.html. [Accessed 23 November 2019].