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Certificate of authorship

We hereby certify that this material, which we now submit for assessment on the programme of study leading to the award of BSc in Computing is entirely our own work, and has not been taken for the work of others save and to the extent that such work has been cited and acknowledged within the text.

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## **Abstract**

PathFinder came to life due to issues some of the team members (and their friends) had while attempting to navigate through buildings where GPS does not work. Our research was specific to solutions from business and other organisations where research (and solutions) has/have been done to see if it is possible to assist users to find their way around buildings. A lot of the examples we found, either were costly or designed more around the business goal rather than assisting the user. We were looking for something that was focused on the user and getting them to their destination.

After completing our research, we decided that a simple solution, using QR codes and Barcodes (Bluetooth beacons and NFC Tags, if time and costs allowed), would be sufficient to allow us to find where a user is, to then allow the user to select a destination. Our solution could then show to the user a list of text instructions on how to get there.

There appears to be a market opportunity for a simple application that would allow the user to navigate between two points, either indoors or outdoors, where existing GPS solutions do not work due to either lack of GPS or due to indoor / outdoor mapping requirements (e.g. nature trails, forest walkways).

# **1 Introduction**

PathFinder is an application (Android Phone or Tablet), that allows to a user to find the way around supported buildings and areas, so if a user entered into a building, such as LIT, an app could be downloaded and person will instantly have an access to an interactive map of LIT, which has the ability to display all room names, numbers and other specific information about the room, such as timetables etc. In other words, PathFinder is a navigation software for buildings and path trails. An app displays different room locations on a map and a path, which the user can follow to reach the intended room, following the optimal path. The implementation of the indoor navigation system is to have specific sensors laid throughout building, which are going to interact with user's device to track user's location in the building and based on the provided information be able to set a path.

The development of PathFinder involves different technologies: Azure for the projects database and web hosting needs; Bluetooth Beacon, NFC tags, QR Code and Barcode technology for the hardware needs.

The major target of usage will be colleges, hospitals, airports. Buildings, where people usually most struggle to orientate themselves in. The main goal to achieve not just develop a cheap & cheerful version of an indoor GPS system for people, but also make it precise & efficient one as much as possible, by using mix of technologies mentioned above.

## **2 Problem Definition and Background**

### **2.1 Problem definition**

As everyone knows, GPS can't be used in indoor environments, because signals from satellites do not move easily through solid objects such as brick, metal, stones & wood. All these materials usually used for making buildings & make it very difficult for GPS signals to pinpoint person's location accurately indoors. The solution is IPS – Indoor Positioning System, which is the next generation of positioning technology, which helps to beat limitations of GPS. Indoor Navigations System technologies are being developed by Google, Microsoft, Nokia etc.

## 2.2 Technologies used & Market

Based on the research of the current indoor navigation systems on the market to better understand advantages & disadvantages of products and how to make PathFinder system better than the existing systems on the market now, by trying to implement different solutions and also by developing a system that is much lower cost than bigger companies pricings for their IPS products, which charge an extremely large amount of money.

There are several types of wireless technologies are used for IPS: WLAN, Wireless Bluetooth techniques (used for PathFinder system), Infrared (IR) techniques, Ultra-wideband (UWB), Ultrasonic system & Cellular based techniques, etc.

List and brief descriptions of some technologies that, most commonly, are used to solve the indoor navigation system:

- WLAN – a wireless local area network with added a location server. Range is 3 - 30m. Technology using RSS help, which is another technology that collects updates to renew the system every few seconds.
- Infrared (IR) techniques – using infrared light pulses, like in TV remotes, to locate the objects inside. It has a simple structure, low cost and quite high accuracy. In every room installed IR receiver device and when IR tag pulses – it received by device. Minus of this technology that it cannot pass through obstacles and has short data transmission distance.
- Ultra-wideband (UWB) – a new communication technology sending and receiving nanosecond pulses to transfer the data. This technology gives a precise indoor positioning, it has a low power consumption, high security & low complexity. Used a lot in military.
- Ultrasonic system – using a triangulation positioning algorithm to locate objects. It offers a high accuracy, simple structure, but needs a huge hardware infrastructure investment that will cost a lot.
- Cellular based techniques – is using a global system mobile cellular network to locate mobile clients. Range 50 – 200m, depends on infrastructure, if there is several base stations with RSS or one station with strong RSS.

There are a few companies that on a market that offering the Indoor Positioning solutions:

- 1) Insoft company from Germany, which provides a leading indoor navigation products such as Indoor Positioning, Tracking & Analytics solutions for businesses, which are used to map out warehouses, to track in which zones of store customers spent most of the time for future store optimization & to guide automated vehicles in the same warehouses. Insoft company is using technologies such as: Wi-Fi, Bluetooth beacons, Ultra-wideband, RFID.
- 2) Eliko company from Estonia, also provides solutions for such industries as Biomedical, Logistics & Warehouse, Manufacturing industries. Eliko is using Ultra-wideband technology as well. Also, company has an indoor & outdoor positioning solutions and tracking systems. At company page, researches are posted, that have been done, how everything works and even pricing for products.

### **2.3 Objectives**

This project aims to create an interactive map for any building using an extremely low-cut budget but will be able to deliver an effective and easy to use application.

The idea behind this app is to make something that is simple to use, simple to maintain and update, and easy for everybody to work with.

### **2.4 Project Scope**

The Product scope requires:

- a website that organizations can register and log onto, user will be able to upload, delete, and edit new Maps of their buildings with an information on each checkpoint.
- a database that will store information on both the website and application and the ability to manipulate from both apps.
- (for the application) that the user will be able to use the application to download a map from any listed buildings, the user will scan a QR code to check a current location, this will be a checkpoint, the user will then select another checkpoint on the map and an icon or waypoint will be displayed to user to guide to the destination.

- hardware supplies – Bluetooth beacons, NFC tags were ordered, and QR codes & Barcodes were generated for precise user's location on the map, then based on provided data to set up the path to the destination.

## 2.5 Deadlines

Deadlines and roles have been laid out in specified Gantt chart, which displays all features and their breakdowns and including the man-hour's each section will take.

This is the initial page of team's Gantt Chart which display all the phases of our overall project and there deadlines which are specifically highlighted in yellow, on the right side of the screenshot is the visual representation of our overall schedule and deadlines, the full Gantt chart is viewable in Appendix A.

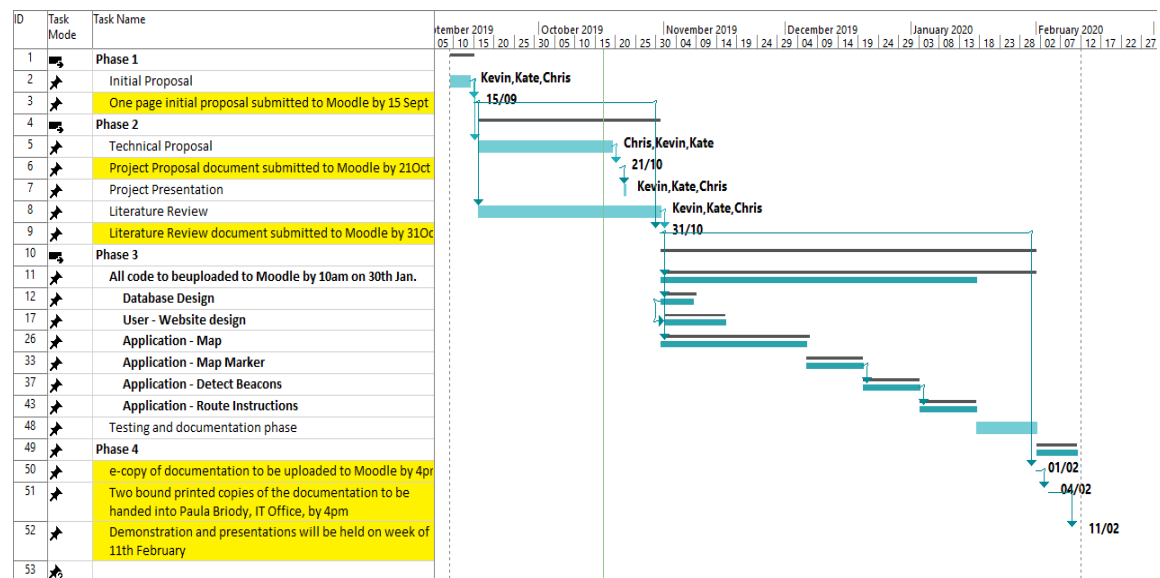


Figure 1. Gantt Chart.

The full feature breakdown structure and the sprints in Excel format are available in Appendix B.

## 3 Literature Review and Research

### 3.1 Pre-existing Technologies

The first thing that was researched was about the different companies that have implemented or are planning to implement indoor GPS navigation and companies who are doing research and are inventing new tools to make implementing this technology easier.

The first company that was researched was Infsoft, which was briefly described before already, which is the one of the leading indoor navigation companies around. The research, that was done, helped to explain and understand exactly how this company was using their software in conjunction with hardware to map out their warehouses. (Infsoft.com, 2019)

The hardware, that was used, was a Bluetooth beacon to setup positions inside a building in conjunction with Wi-Fi to have a constant signal which can be used, also Infsoft Locator Nodes and Infsoft Locator Tags were created, which actually allow to track people and assets in real time in any of their buildings. (Infsoft.com, 2019)

The most interesting aspect of indoor navigation is the absolutely amazing amount of versatility, which offers different people and companies through tracking different machines, packages, people in factories and collecting analytical data to help optimise their system and work output, one of the most surprising things, that was discovered about this, was - how it is possible to track different customers inside a shop, that has a specific layout, to see how much each person spent at one zone or what path they choose to take. Information like this has an immense value to business owners, in example, to help to optimise the store to make more money. (Infsoft.com, 2019)

One of the most important factors in indoor GPS navigation was the essential need for reliance, one important factor – showcases, what would happen if multiple vehicles, that were all automated and guided by an indoor GPS navigation system, were not efficient and caused different vehicles to run into each other, causing untold amounts of damage. This is a very real and serious situation and has the potential to be quite dangerous for people as well, because of congestion in buildings or vehicles moving around that had incorrect sensors that might crash into a person. All these factors must be considered when designing such systems.

GiPStech is another leading indoor navigation technology company, that has been paving the way for a variety of new advancements, involving indoor navigation. This company has created a new way of creating an indoor navigation system by using an infrastructure free, which involves the use of no Bluetooth beacons. This is a massive step forward in indoor navigation, because most companies use standard or specialized beacons as the focal point of their entire indoor navigation system and because the next generation of

indoor GPS navigation seems to be moving away from this and just using Wi-Fi signals and the geomagnetic signals that were already installed in the location as the data sources to accurately pinpoint the location inside the building. (GiPStech, 2019)

### **3.2 Upcoming Technologies**

The constant advancement of indoor GPS navigation technology has been steadily increasing as the incredible importance of this technology grows, increasing more essential in everyday life. The benefits this technology offers are incredible and because it is used in so many applications, which nearly all ask for or require a GPS location. The need for a more sophisticated GPS location-based software has been steadily increasing, which has seen a variety of companies around the world, which invest heavily into sophisticated and low-tech solutions, such as Google, Apple and Infsoft.

The future of indoor GPS navigation is constantly changing and evolving. One of the biggest reasons for the push is customer convenience. The customer wants to find the way around a building quickly and easily, but this can be enhanced by connecting navigation apps with different retail shops inside a shopping centre. For example, the next logical step is for a person, who is looking for an item online, then connects that to their GPS navigation application and be delivered a real time path inside a building to that item - this is the future of indoor navigation. The technology of such type of delivery does not exist in just one form, but many forms such as Bluetooth navigation in conjunction with real time location technology all of these will come together in the future to deliver this incredible accurate technology. (Directionsmag.com, 2019)

### **3.3 Web Hosting**

The web hosting companies, that were researched, were Amazon Web Services and Azure Hosting. The first company was Amazon Web Services, which offered a free 12-month subscriptions on multiple different services such as database, web hosting etc., which the project needs for a variety of roles.

The first thing, that was looked, were the differences between the 2 different services just to check - did either have any large negative service that would impact the project and the research concluded, that both companies offered quite similar services with negligible differences.

Azure hosting is the main hosting company, which will be used for the project's database and web hosting needs in the application. The research concluded, that students actually have a free 12 month subscription, because the college created students accounts with Microsoft, which allows the students to use all Microsoft applications, including Azure, which is an incredible benefit to the project, because of the wide array of options it offers, allowing the project more flexibility, also saves money by not needing to use other hosting applications which depending on the company are either lower quality hosting sites or reliable and good hosting companies, which charge an extraordinary amount of money and what the project could not afford.

Amazon Webserver offers very good services, but the reason Azure Hosting was chosen is because the research, that was undertaken, lead to the conclusion that Azure offers the best mix of these services compared to the other hosting companies. List of advantages includes:

- Availability
- Azure Software Development Kit
- Scalability and flexibility
- Stability
- Recovery
- Integration Tools

The Azure application allows the use of a variety of different development environments such as Eclipse, Visual Studio, NetBeans, MySQL and many more. This offers to the project an immense amount of flexibility, because all these applications have a variety of tools, which can be used for a great effect in the project. The Azure web hosting technology requires .net framework experience, which is problematic, because it is not taught, but the benefits of being able to use other IDEs is because Azure is cross-platform, friendly.

The Azure application can be used in conjunction with GitHub to pull new code from the project repositories and used to update both the web front-end and database backend of the project, which offers a flexible and stable backup and upload centre.



Azure hosting had a nice mix of all these features and even more that helped to realise that this is the best choice for the project. (TechRepublic, 2019)

### **3.4 Bluetooth Beacon Technology**

Bluetooth Technology was begun in 1989 by Dr. Nils Rydbeck and Dr. Johan Ullman. First goal was to make wireless headsets. After that each generation of Bluetooth was adding new features to it.

Bluetooth Beacons is hardware data transmitters at short-wavelength radio waves, from 2.4 to 2.485 GHz, between two and more devices that are near and performing actions when a device is close to the beacon. This technology usually used to determine physical location & to respond as a location-based action to a device. Bluetooth Beacons come in variety of forms, from coin-size cell to USB stick.

The idea of how Bluetooth beacon works:

1. Information broadcasted from a beacon
2. Phone receives information and sends to backend systems
3. Analytics backend systems receive and process the data
4. Notification is delivered over network to mobile application

From Bluetooth 4.0 version, it is possible to have one-way communication, when Bluetooth device just transfer the data, but not listen for it. Also, it works with less impact on the battery life and with good extended precision.

Bluetooth Beacons come with variety of powering design as well: battery powered, which the project is going to use, & USB powered, which are good for a long-term installation option. As the project is going to use battery powered beacons then the manufacturer specifications related to power consumption, interval transmit power, also must be in count approximate frequency of usage and think by what kind of phones, it might be use. Battery powered beacons life range is about from 1 month to 2 years.

There is two most popular version of this technology – 4.2 and 5. Bluetooth 5 improved version, of course, with more speed, which is 2X times higher than at 4.2 - 2 Mbps against 1 Mbps & with more range, which is 4X times higher – till 40 metres indoor

range. Power consumptions of Bluetooth is less than previous version & battery life is longer. Also, capacity of message larger, 255 bytes against 31 bytes.

The project plan is to use about 2-3 beacons per building, just as checkpoints of user's location.

Mobile Device support – Android and iOS do not do it natively and a generic application is needed for that.

Other usage of the beacons is location-based advertising, healthcare (in-home monitoring), customer data collecting for improving customer loyalty with special offers, payments accepting etc.

### **3.5 NFC Tag Technology**

NFC tags (abbreviation for Near Field Communication) are basically, small stickers, of round or square shape and the size of the coin, with an integrated circuit that able to store data and transfer it between NFC-enabled devices such as smartphones and tablets. In wireless world, NFC's closest relative is RFID, which stands for Radio Frequency Identification. NFC readers work at approximately 10 cm of maximum range.

NFC tags are passive, because they don't have any power source. They take power from the device that reads them by using magnetic induction. When reader-device gets close enough to an NFC tag, it energizes the tag and then transfer the data from the tag. There is always some power lost during the transmission, but it is usually still enough to power the NFC tag. They 'steal' a bit a power battery of the phone to kick in, basically.

NFC tags can be with different memory capacities. It's possible to store a telephone number or URL (web address), also there is opportunity to add the protection – NFC tags can be locked, once data has been written, it cannot be changed. They can be re-encoded a few times before they are locked forever. During the research, 5 different types of tags were found, with different capacities and data transfer speed:

Type 1 & 2 store from 48 bytes up to 2 kilobytes of data and communication speed is up to 106 Kbit/s. These types of tags can be rewritten several times and be permanently locked, so no one could apply any changes to data. These tags able to store something short like a website URL – a simple piece of information.

Type 1 is used for read-only applications, business cards etc. Type 2 is more popular, because offers more functionality and has relatively cheap price. Type 2 used for low-value transactions, event tickets, URL redirects etc.

Type 3 stores up to 32 KB and communication speed is up to 212 Kbit/s. It provides a wide range of the functionality, but price is quite high. These types can be written only once and has the lack of security. It used for more complicated applications such as E-tickets, electronic ID, membership cards, etc. It is very widely used in Asia, because it is Japanese innovation.

Type 4 has the same capacity, but speed is up to 424 Kbit/s and offers most of the flexibility and memory but has high price for it. Also, it provides a good security.

Type 5 is used for library books, products and ticketing applications.

It's a quick and efficient way to push any information to your phone. Also, they are very cheap to make, maintain and can be used for wide range of apps.

### **3.6 Barcode & QR Code Technology**

#### **3.6.1 Barcodes**

“The barcode was invented by Norman Joseph Woodland and Bernard Silver and patented in the US in 1951. The invention was based on Morse code that was extended to thin and thick bars.” (En.wikipedia.org, 2019)

“Barcodes became commercially successful when they were used to automate supermarket checkout systems, a task for which they have become almost universal. Their use has spread to many other tasks that are generically referred to as automatic identification and data capture (AIDC)” (En.wikipedia.org, 2019)

“GS1” is a company that provides barcodes to organisations and has a comprehensive list of steps that can be followed to obtain a barcode (see link above). A barcode consists of a prefix of 2 or 3 characters and a company number, which can be assigned to an organisation by GS1 (and other companies). Once these are assigned, then a decision has to be made as to the type of barcode to be used, from a simple code, to one that can contain URL information, from codes to be used at a POS device (must support omni-

directional scanning), warehouse (larger size codes for distribution scanning) or healthcare items (omni-direction scanning not required), all require different types of barcodes. (Gs1.org, 2019)

The project will have the capability of be using bar-codes that have been generated by either a web-service or program. The project will be using a variety of options when it comes to enable the generation of barcodes for use within the project / application, to allow the users of the application to identify where they are. (Windows Report | Error-free Tech Life, 2019)

Since the generated barcodes are compliant with current standards, any standard or conventional barcode reader will be able to read the generated barcode. The options that were researched has shown that it is possible to install onto an Android Phone, an App that can read both Barcodes and QR codes, and this can be used to test the readability of the barcodes that have generated. (wikiHow, 2019)

### **3.6.2 QR Codes**

QR code (abbreviated from Quick Response code) is the trademark for a type of matrix barcode (or two-dimensional barcode) first designed in 1994 for the automotive industry in Japan. A barcode is a machine-readable optical label that contains information about the item to which it is attached. In practice, QR codes often contain data for a locator, identifier, or tracker that points to a website or application. A QR code uses four standardized encoding modes (numeric, alphanumeric, byte/binary, and kanji) to store data efficiently. (En.wikipedia.org, 2019)

QR Codes are now very common and can be found almost anywhere and nearly all smartphones can scan a QR Code and act on the contents of the QR Code. From bringing a user to a site, allowing for payments, for virtual store shopping, website and Wi-Fi network logins to the ability to have QR codes engraved on headstones so that visitors to a gravesite can find out about who was buried there and possibly, information about their life.

Since QR Codes are now so common, it is nearly mandatory for the project to be able to read QR codes as they are very easy to generate, the same websites and applications for barcodes can be used for QR Codes. Users of the project / application may be more

familiar with scanning in QR Codes than Barcodes, but the project / application will support both methods, as well as Bluetooth beacons and NFC Tags.

## **4 System Design and Configuration**

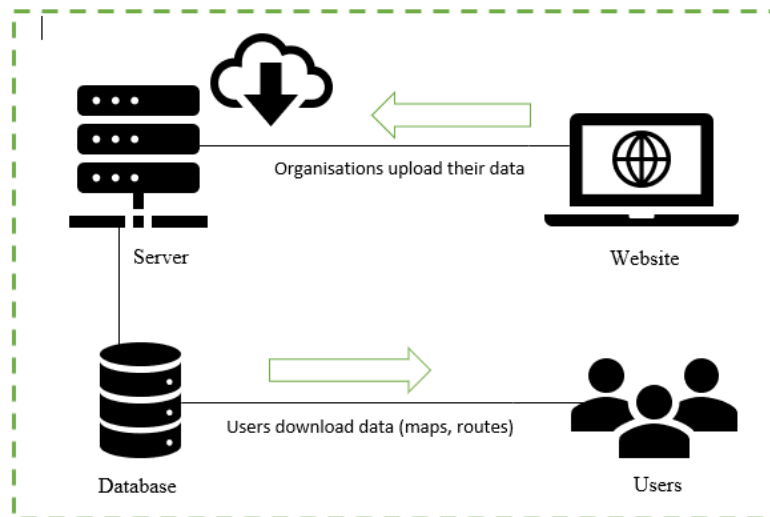
### **4.1 System Architecture**

#### **4.1.1 Requirements**

In order to implement this system, the project requires:

- Azure Hosting of the Database.
- Web Hosting for the users / companies – show info on the production for users and to allow companies to upload their data and waypoints.
- Android App will be the main user interface and will consist of
  - Landing screen with information about application.
  - Ability to capture where the user is and what maps / waypoints are needed.
  - Allows user to select where they need to go using a dropdown or icon on the map.
  - Show instructions on “how to get there” form where the user currently is using an icon or text popups.
  - (Optional) Message to inform user when they have reached their Destination and potentially display information on their destination.

This is a high-level diagram (at Figure 2 shown below) showing cloud with database server, linked to a network (for users to check in at home / companies to upload data), business place/college/hospital and user connecting to database to get required details to find the route to where they need to go.



**Figure 2. System Architecture/topology.**

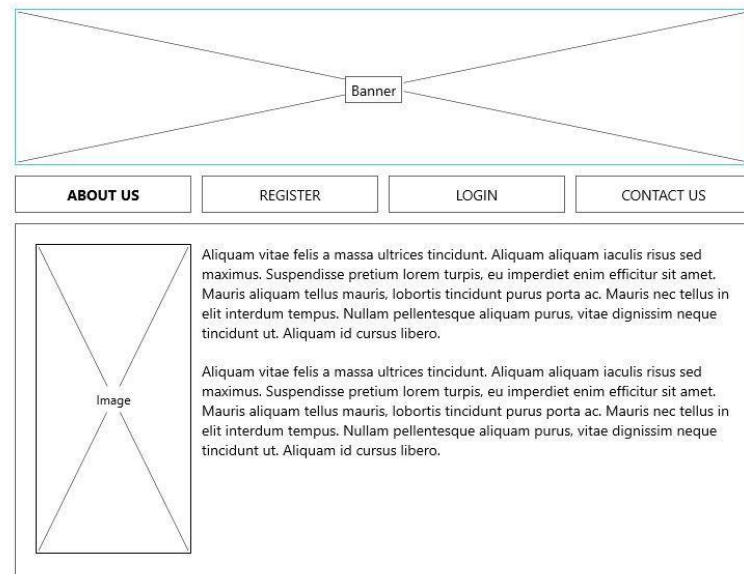
#### **4.1.2 Application mechanics**

The proposed solution has two different interfaces for the users and the companies. In the storyboard below, both are shown.

The web site will allow the user to preview what the application can do. For business, there is an option to register to use the application / database. This will be used to contact the company and setup required information. Companies, once approved, can then login and setup their maps and waypoints. A “Contact Us” page will be available for all general enquiries on the application.

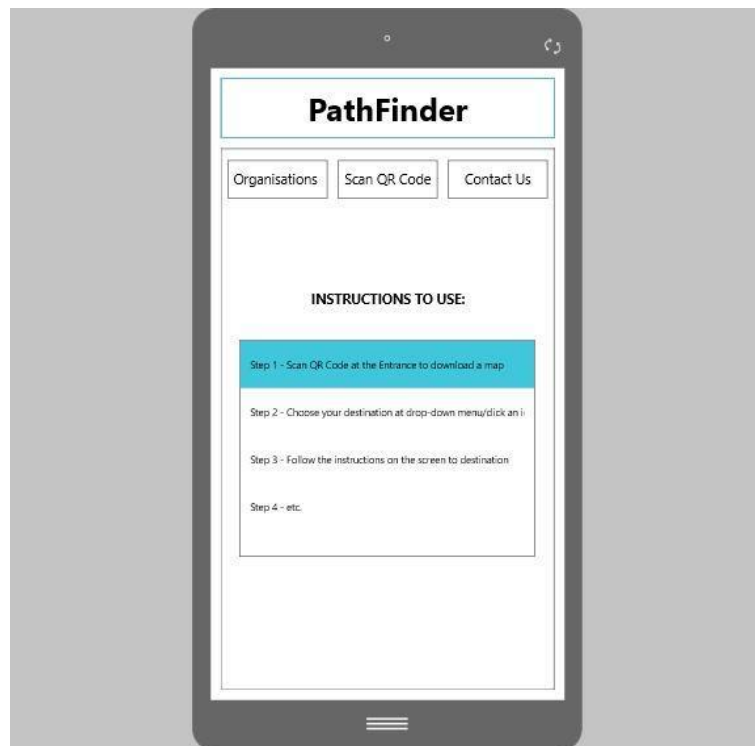
For the Android Application, once launched, the user will have simple instructions on how to use the app. The user then obtains the company information (maps and waypoints) by either Bluetooth, NFC tags, barcodes or QR codes. Once done the map is then presented to the user with a drop-down allowing the user to select where they would like to go. The list of instructions is then generated and shown to the user. The user can obtain updates along the way, either by Bluetooth, NFC tags or by scanning other Barcodes and QR codes.

### 4.1.3 Prototype/Storyboard



**Figure 3. Landing Page.**

This is the webpage for the user/organization so that users are introduced to an application and contains essential information about the product and what to do, see Appendix C for all website screenshots.



**Figure 4. Android application landing page.**

This is the instructions that will be displayed to the user to help them understand how to use the application, all other screenshots that display added functions and features of the mobile application are available in Appendix D.

#### 4.1.4 Architecture Design

Azure hosting will be used as this is, what research has shown, the best suits for the current requirements. This hosting will be for the database and the website. This is one half of our solution and the other will make use of Android phones / tablets.

The Apple systems are not considered at this time as there is insufficient project time available to support two Application developments.

Bluetooth beacons and NFC tags will be supported so that the application can be more automated and easier for the users of the application.

Barcodes and QR codes can also be used but these need to be scanned in by the user and increase the complexity of the application use. It would be easier for the user to use either Bluetooth beacons or NFC tags, but all methods can be used, and they can all be available for a business (mix and match approach).

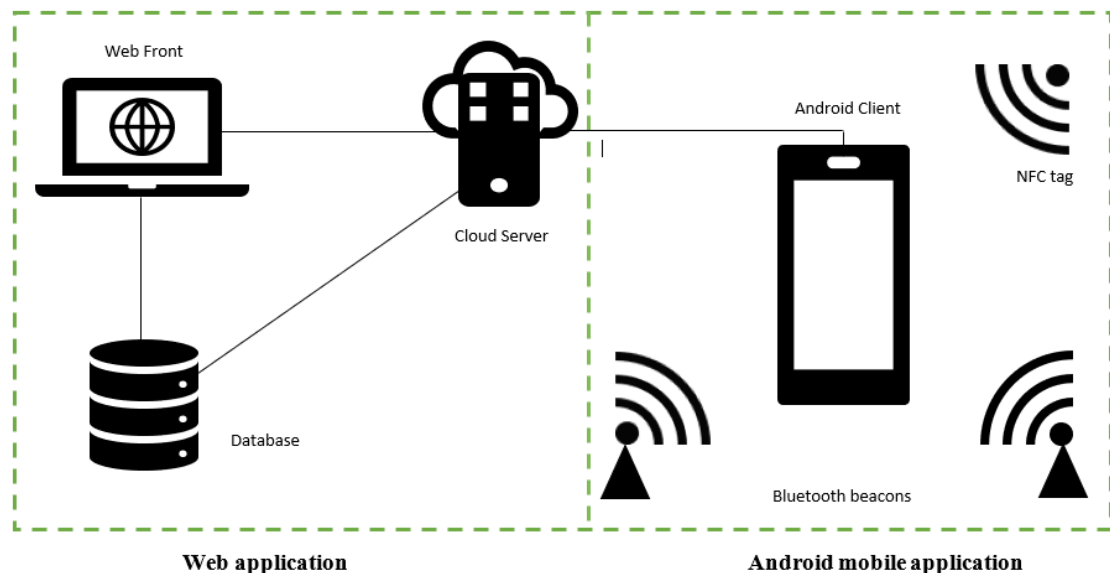


Figure 5. System architecture/topology.



## 4.2 Configuration

### 4.2.1 Web Application

#### 4.2.1.1 Database Design

This is our database ERD diagram that was used for our project database, this ERD was designed using the MySQL Workbench ERD diagram tool, this helped our team to recreate a variety of different iterations for our team's database quickly and efficiently, the diagram below is the final database diagram iteration.

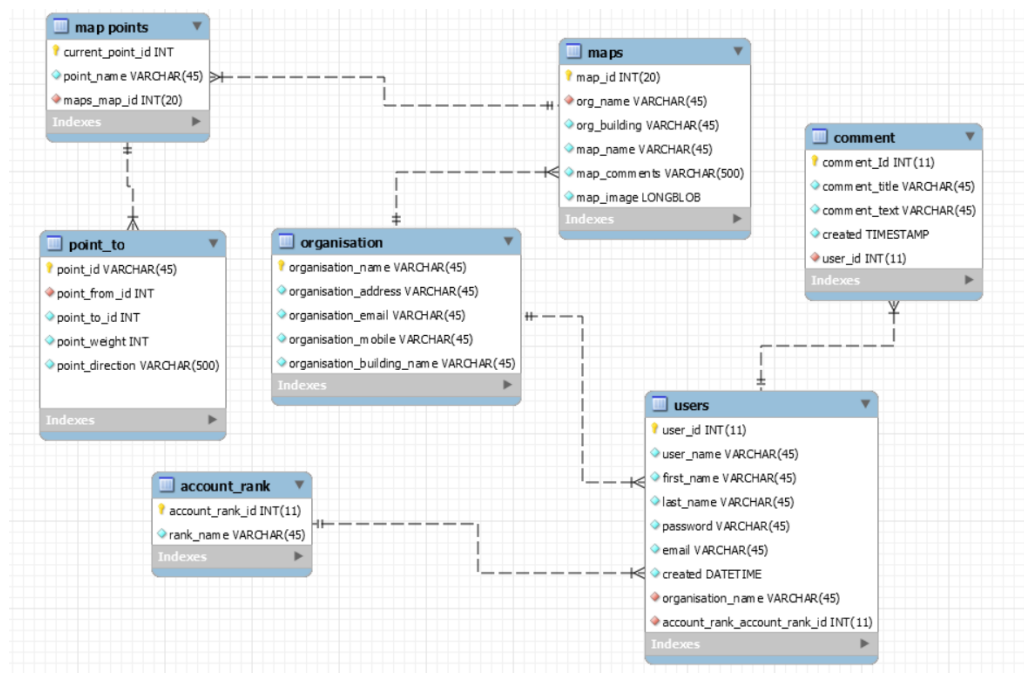


Figure 6. ERD diagram of our database.

#### 4.2.1.2 Azure Hosting

The Azure Cloud Computing service has the ability to host website's for free to student and this is the application we used to host our website "https://pathsearcher.azurewebsites.net/", the process involved in setting this up required our team to setup a resource group called Path, this resource group puts all the database and websites our group used under the one umbrella, once this has been setup our group could now create a website.

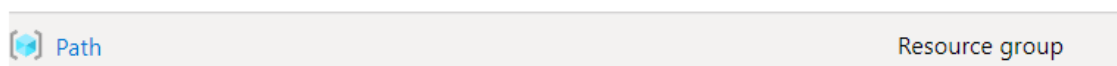


Figure 7. Azure resource group path.

#### **4.2.1.3 RemoteMysql**

The Azure database software had a large learning curve and used an incompatible SQL database that our group was not familiar with, this led us to the decision to change our database hosting site to a easier to use one which lead us to RemoteMySQL.

This is a free database hosting company that we used to create our database, there are also some downsides to using this application compared to using the Azure SQL database and that is the speed that we can access this database, because it is a free database it has very limited ability to handle multiple interactions simultaneously or even just one person using the mobile application to rapidly access the database repeatable, this is a large downside but because it is free our group has tolerated this downside and because we have the code for our SQL database we could rapidly switch to a more advanced database for better speed.

The downside of this is problematic at times during our team's testing phase which is why our group used a local database using MySQL workbench which allowed us to rapidly test our application without any delays which speed up our testing phase.

#### **4.2.1.4 phpMyAdmin**

The database management tool that our group used was phpMyAdmin, this tool was something we have extensive familiarity with and was a bonus to our project for this reason, phpMyAdmin is a very simple and easy to use application which allowed our group to very quickly setup an online database which our group used to access through our IDE Eclipse for local development and through our Azure website, its ease of use allowed us to quickly upload a pre-configured database by either entering through the console or uploading an SQL file directly.

This application also allowed our group to quickly and efficiently access and view our records to test and maintain our data in a variety of ways.

Table	Action	Rows	Type	Collation	Size	Overhead
<input type="checkbox"/> <b>account_rank</b> ★	Browse Structure Search Insert Empty Drop	2	InnoDB	utf8_general_ci	16 KiB	-
<input type="checkbox"/> <b>comment</b> ★	Browse Structure Search Insert Empty Drop	0	InnoDB	latin1_swedish_ci	32 KiB	-
<input type="checkbox"/> <b>maps</b> ★	Browse Structure Search Insert Empty Drop	4	InnoDB	utf8_general_ci	1.5 MiB	-
<input type="checkbox"/> <b>map_points</b> ★	Browse Structure Search Insert Empty Drop	20	InnoDB	utf8_unicode_ci	32 KiB	-
<input type="checkbox"/> <b>organisation</b> ★	Browse Structure Search Insert Empty Drop	2	InnoDB	utf8_general_ci	16 KiB	-
<input type="checkbox"/> <b>point_to</b> ★	Browse Structure Search Insert Empty Drop	43	InnoDB	utf8_unicode_ci	32 KiB	-
<input type="checkbox"/> <b>users</b> ★	Browse Structure Search Insert Empty Drop	4	InnoDB	utf8_general_ci	48 KiB	-
<b>7 tables</b>	<b>Sum</b>	<b>75</b>	<b>InnoDB</b>	<b>utf8_unicode_ci</b>	<b>1.7 MiB</b>	<b>0 B</b>

Figure 8. phpMyAdmin displaying SQL tables.

#### 4.2.1.5 Postman

The Postman application is an google chrome application that can be used to test HTTPS API's for use in a variety of ways, our group heavily used this application to test our JSON RESTful web service API's to see how they worked and interacted and to see if our JSON data was being delivered as our group had specified and to see it displayed in the exact way we had intended.

GET [https://pathsearcher.azurewebsites.net/ActionJson?org\\_name=Limerick Institute of Technology&org\\_building=LIT Thurles](https://pathsearcher.azurewebsites.net/ActionJson?org_name=Limerick Institute of Technology&org_building=LIT Thurles)

Params Authorization Headers (7) Body Pre-request Script Tests Settings

Query Params

KEY	VALUE
<input checked="" type="checkbox"/> org_name	Limerick Institute of Technology
<input checked="" type="checkbox"/> org_building	LIT Thurles
Key	Value

Body Cookies (1) Headers (6) Test Results

Pretty Raw Preview Visualize BETA JSON

```

1  {
2    "map_points": [
3      {
4        "maps_map_id": 1,
5        "current_point_id": 1,
6        "point_name": "Front Entrance",
7        "special_points": [
8          {
9            "point_id": 1,
10           "point_weight": 2,
11           "point_from_id": 1,
12           "point_direction": "straight_ahead",
13           "point_to_id": 2
14         },
15         {
16           "point_id": 2,
17           "point_weight": 2,
18           "point_from_id": 1,
19           "point_direction": "straight_ahead",
20           "point_to_id": 1
21         }
22       ]
23     }
24   ]
25 }

```

Figure 9. Postman returning JSON request.

#### **4.2.1.6 Maps & Points Setup**

The Maps and Points setup in our project is the single most important factor and was one of more difficult to develop and implement, the idea behind the maps and points was to have two tables in a database called “map\_points” and one called “points\_to”, the first table map\_points needed to hold the 3 pieces of information the a random int number, the name of that point and the map that connects to that point, this three pieces of information are of vital important because it identifies the point identity and which organisation this point connects to by the map id.

The point\_to table is of vital important to our project because it is the second most important piece of information that connects the individual points of our map, it holds 5 pieces of information which is the point\_id, from\_point\_id, point\_to, point\_direction and point\_weight, these 5 pieces of information map up the strings that connect each point on our map and without them our project would be incapable of functioning.

The actual setting up of the map requires the user to select a from and a “to” destination and this is made easy by our teams idea of using drop downs to help the user to select where they are going from and going to instead of our original idea of using integers which would be confusing, the only thing that the user would have to input is the weight to get to a location and also a direction which has been made easy by the use of another drop down table which has 5 pre-existing directions to choose from.

#### **4.2.1.7 Website**

The pathsearcher website is the cornerstone of our team project because of how it is used to create and handle our map information, one of the most important factors of our team project is how we upload a graphical map of our building, this graphical map contains the point names so the user has an easy idea how where each point is on a map for ease of us.

The second most important use of our team project website is the creation of the points which include the point name and the points drop downs that help guide the user in creating the map, this is one of the most important pieces of our group website because without it our project would not be able to function without these crucial pieces of information.

The pathsearcher website has 2 RESTful Web API's that are crucial because they connect the android mobile application to the RemoteMySQL SQL database, the way both of these web APIs work is by accessing the SQL database and pulling information from the map\_points, point\_to, maps, and organisation tables, the information from these tables are then formatted into a JSON object and organised into JSON objects with embedded arrays to hold the information in such a specific way that it connects all the points together as seen in the figure below which shows how 1 point location is connected to multiple other points on map.

```
map_points: [
  - {
    maps_map_id: 1,
    current_point_id: 1,
    point_name: "Front Entrance",
    - special_points: [
      - {
        point_id: 1,
        point_weight: 2,
        point_from_id: 1,
        point_direction: "straight_ahead",
        point_to_id: 2
      },
      - {
        point_id: 2,
        point_weight: 2,
        point_from_id: 1,
        point_direction: "upstairs_hallway",
        point_to_id: 8
      }
    ]
  },
]
```

Figure 10. Nested JSON array displaying connected points.

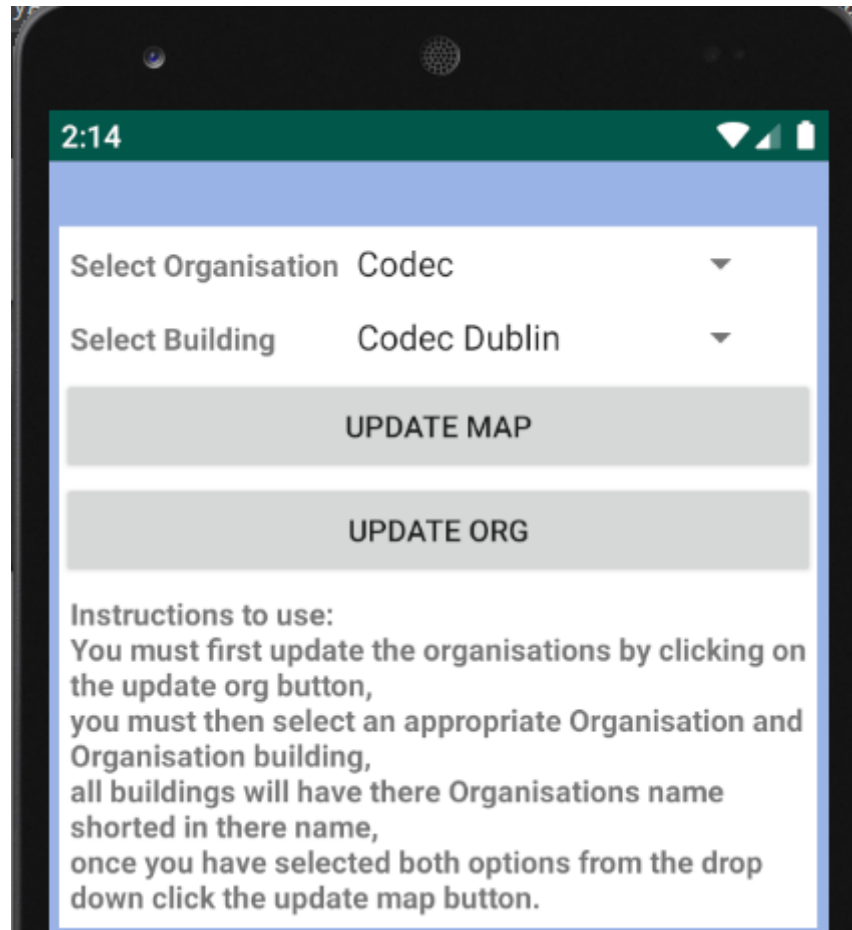
## 4.2.2 Android Application

### 4.2.2.1 SQLite Database

The android application uses SQLite database library as our local storage for all our information from the RemoteMySQL database, this information is first accessed through the website using a RESTful Web API that pulls information in a JSON object and this

information is then formatted multiple ways and stored in our local SQLite database called “Maps”.

This local database is used throughout our application to display the different organisations that they user can select which will then display map information specific to the Organization and the Building name of that organisation they have chosen.



**Figure 11. Dropdowns showing information pulled from the website through the use of a REST API.**

The options that have been chosen are passed to the Update Map which then calls the Web API and adds the details to the local SQL database to be used throughout the application.

#### **4.2.2.2 QR & Barcode Scanner**

The scanner that the mobile android application uses can scan Bar codes or QR codes which have text embedded into them, this Scanner will then read that text and use it to find the current location for the user which they will then use to choose a destination.

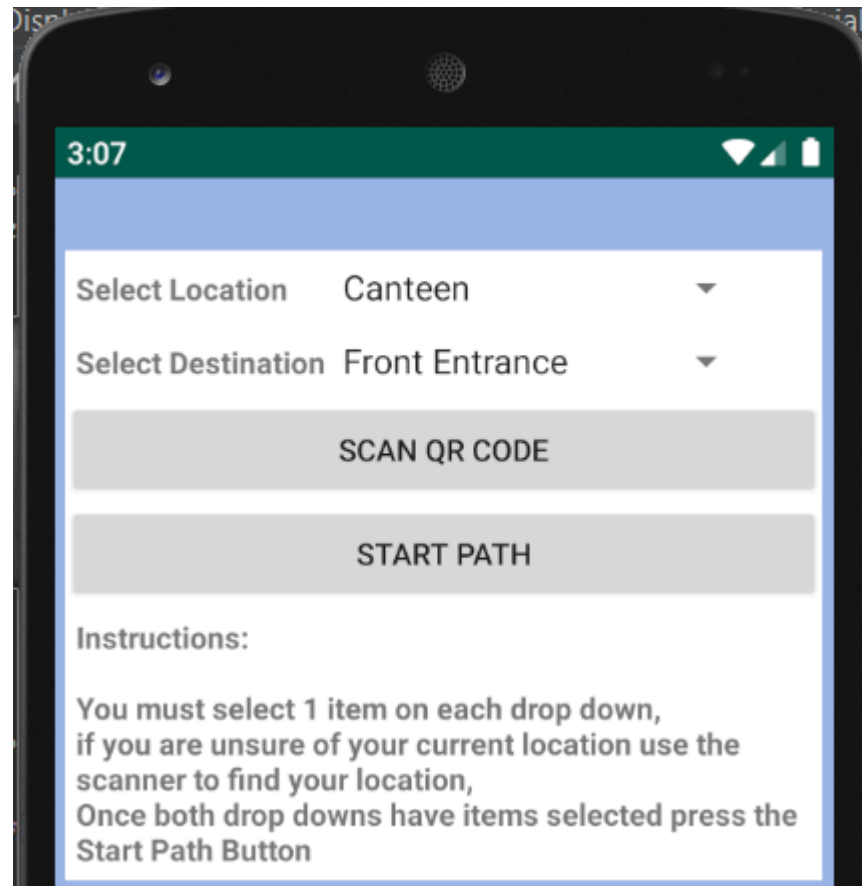


Figure 12. Scanned QR code and now has automatically displayed the canteen as their current location.

#### 4.2.2.3 Building the path

The Path that our application needed to display had 3 main issues which we had to take into consideration when designing out graphical display and the back-end algorithm.

1. How to get from point A to Point B,
2. How to determine which path is quicker.
3. Displaying the path to the user

These factors where essential in setting up and determining how our Pathfinder would work, the algorithm our project used was the Dijkstra's Shortest Path Algorithm using undirected weighted graph, this was easily done because our group had an assignment, based on that, to create a directed graph so our team did not need to reinvent an algorithm.

The Dijkstra algorithm that we used took in 3 important details, the starting point, the ending point and the weight so we had a cost to traverse this path, the algorithm then

setup a tree on the source destination and built shortest paths to every single node on our tree so we could determine the shortest path to them all, the next step was to create a stack and a queue to traverse the smallest weighted path so that would become our shortest route.

There was an additional problem setting this up because the points to create the path could only accept numbers between 1 and N. this presented a significant problem that was corrected by changing the random numbers when the web API was called and just before the data was inserted into the local SQLite database, this function swapped the points in both the map\_points and special\_points tables to change all points on the map\_points table to follow a pattern of 1 to N instead of the random numbers such as 20,24,45 etc, this change also swapped the old number in the special\_points table to have the new number in the map\_points table, this corrected our problem of taking in random values so they could now work with our path algorithm.

The last problem the Dijkstra algorithm had was actually displaying the shortest path which was problematic because it only stored the number of the point and not the actual name, this meant that the android application had to have a function to correctly match and display the points from the map\_points table and then store the matching point name inside an Array which would be used to display the correct path information for the user in an understandable fashion.

## **5 Example of use**


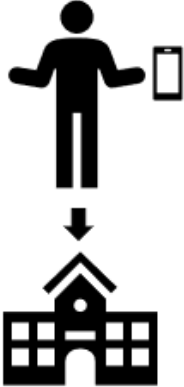

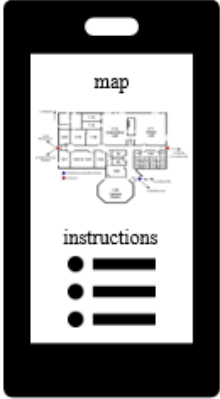
Solution can be used in any building and areas, where the app is supported. User can download the application and use an interactive map of the current building to navigate around it, just simply scanning QR or Barcode provided around the building or area, which must show the current user's position. Based on this information and picking the desirable destination from the drop-list at the Android App, then App should provide navigation instructions to reach the destination.



In practice, it should be very useful in buildings as colleges, hospitals or airports, because it is easy to generate QR and Barcodes, to implement the app and use it, and also related to pricing of the whole project – it is very low.



Due to time constraints, we managed to map the building only using the QR & Barcodes and by using Use Cases, the basic application set up and instructions, how to use it in real world, will be provided below:

**Table 1. Use Case/Storyboard.**

 <p>1) Download the App</p>	 <p>2) Walk into the building</p>
 <p>3) Scan QR Code at entrance</p>	 <p>4) Get a map, pick the destination</p>

 <p>5) Follow the instructions</p>	 <p>6) Get a notification, that the destination is reached</p>
---------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------

## 6 Testing & Implementation

### 6.1 Quality Assurance Basic Plan

As the primary purpose of this software is to get a user from one point on a map to another point on the map, we have to make sure that the user is urged to follow the suggested path while taking care of their surroundings (walking on paths, crossing roads with due diligence, etc.)

In order to achieve this and ensure the quality of our software, testing of all sprint aspects must be done by all team members to ensure that there are no issues with the software, the results and the maps, instructions that are shown to the user, if the software is not of high enough quality, then the following is possible:

Web application:

- Site not available for users
- Site not allowing users to login / logout
- Site not updating companies' data correctly
- Site not responding to app API requests

Detailed testing of each sprint and the system components will ensure that the site is working and responding as needed.

Android Application:

- Not launching correctly
- Does not scan (barcodes or QR Codes)
- Bluetooth and / or NFC not working
- Incorrect Maps / Way Points downloaded
- Bad path to destination generated (long way instead of best way)
- App not updating correctly

Detailed testing of each sprint by all team members will ensure that the app was developed as needed and that all features work as per expectations.

## **6.2 Testing & Test Plan**

Testing is important part of Software Development Life Cycle, because it increases software quality, discovering errors and bugs, when the whole development process is completed. Testing's goal is to ensure that the software behave as expected by giving wanted result/output. Some errors might be small and not that important, others can cause real damage like financial loss or be a life threat. There are different types of testing that used in SDLC, that covers different parts of the product. Most known are Black-box and White-box, which also have number of levels of software testing.

Different types and levels of testing will be applied to the PathFinder project to see does it meet basic user requirements and, hopefully, to improve the level of the product quality, in general.

### **6.2.1 Black-box**

This method is used to test the software without knowledge of internal structure of it or knowledge of the coding. The method is done by testers, usually. Testing is applicable on higher levels of testing and mostly covers functional and external testing.

Techniques that will be used for the project are: Boundary Value Analysis and Equivalence Partitioning and Error Guessing, which will be applied in the Test Plan.

Types of Black Box Testing that might be useful are mostly major types of Functional Testing part, which are: Integration Testing, System Testing, Regression Testing, User Acceptance Testing, and some types of Non-Functional Testing such as: Usability Testing, Performance Testing, Compatibility Testing.

#### **6.2.1.1 System Testing**

To test the entire application(s) delivered to ensure a working solution has been provided. This method of testing can be done by Developers and / or Testers. It is whereby a user reads through the Project Proposal and Documentation to get a understanding of what is to be delivered and then to draw up test plans to ensure that what is being delivered, has been delivered and if not, to document any issues, discrepancies and / or any inadequacies in the solution.

**Table 2. Example of System Testing the Web application.**

Test Case	Description	Expected Result	Actual Result	Action
Web001	Access site	Site accessible	Site accessible	Passed
Web002	Contact page working	Page loaded	Page loaded	Passed
Web003	Login page accessible	Page loaded	Page failed to load	Failed – check why

**Table 3. Example of System Testing the Android Application.**

Test Case	Description	Expected Result	Actual Result	Action
AA001	Access application	Application loaded	Application loaded	Passed
AA002	Scan QR code	Scan worked	Scan worked	Passed
AA003	Scroll through maps	Scrolling worked	Scrolling failed	Failed – check why

A side effect of testing both the WEB application and the Android Application, is that the Servers hosing the web site, the web APS's, the database server and all communications between and automatic login processes, are also being tested. If the system does not

respond as expected, then the user reports the issue in the testing case and from there, the developer(s) is able to replicate, find, fix and re-deliver the solution with the appropriate fix applied.

#### **6.2.1.2 Acceptance Testing**

This is whereby we determine if the values supplied to the input generate the correct output that is currently being expected from the system.

Normally, System Testing can be of a generic nature and is to ensure that the system being delivered is in a working condition, when Acceptance Testing can be derived as being related to the solution, how appropriate the solution is and how appropriate the system handles the inputs from the user and if correct outputs are generated,

Acceptance Testing can use any number of methods to generate the test cases and what the results are, from boundary analysis, range analysis, directed input or other means of input of information into the system and how correct that information is.

Within the project, there is a Web Site that the user can view on the internet. Once on the site, the user can fill in a contact form, or a business can register for use of the solution. In both web pages, the user gets to fill in information in a form and that form is then sent to the server, to be stored in the database.

Part of acceptance testing is to make sure that the data entered into the form is correct and relevant, and does not contain any other type of data, than user supplied textual data. If the user inputs any type of coding (HTML, Javascript, SQL commands, etc), the form input should be rejected.

Acceptance testing is to make sure that all parts of the solution work correctly, and that all inputs / outputs follow correctly and that no 'bad' inputs are allowed withing the system. Integrity of data must be ensured when data is being input and that they type of data input matches what has been requested of the user.

#### **6.2.1.3 Integration Testing**

To ensure that parts of the system that connect to each other, can work correctly with each other. In the PathFinder project, there is a web site, an android application, a web

server, a database and technologies to ensure that all of these can connect and transfer information between each other.

As part of Integration testing, we must test and make sure that the web pages communicate correctly with the web server and the hosted database. The web pages on the client may not directly communicate with the database but information input on the web pages, will affect how the web servers actions the request and that may require the web server to either store or retrieve information from the hosted database.

For the Android application, it is necessary to ensure that the application can connect to our web server and not directly to the web database. Going via the web server allows us to check and determine what data a user can have access to, and what they can then do with that data. This is done via web API's (Application Program Interface).

For the web pages and web server, we perform integration testing as the web pages and server are being developed. Test cases can be created to ensure that the web server accesses the database only when needed, only for the information needed, and only sends back the requested data.

For the Web API's, there is the possibility to use third party applications to test if our API is working correctly and if it responds correctly to both valid and invalid requests. Applications like POSTMAN can be utilised to ensure that the API being developed, does respond correctly without the need to develop an actual application that need the requested API.

#### **6.2.1.4 Regression Testing**

Regression testing should be done every time a change is introduced to the system, or when a series of changes have been introduced.

This type of testing uses pre-existing test cases that we have already tested the system with, that we know the system responds correctly to and we know the responses we are to get.

When changes are introduced to the system, we can do an initial check of the stability, validity and working of the system by running these regression tests. If all tests run and return the expected results, then the changes that have been introduced to the system, have not altered or affected the existing system, in relation to the existing regression tests.

As changes are introduced, tested and verified to be correct, then the tests for these introduced changes can be added to the list of regression test cases, thereby extending the regression testing to now include our new introduced changes. Any changes made after this will then be checked against this new list of regression tests.

#### **6.2.1.1 Iterative Testing**

When a developer is writing new code or changing existing code, it is normal to test the code as it is being created, to ensure that what is being developed does in fact work, works constantly and works for all types of expected and unexpected input. To this end, all developers for this project used Iterative Testing.

As a part of Iterative testing, not only is the new code being tested, the existing functionality is also being tested to ensure that the changes being introduced do not cause issues with the existing functionality.

Iterative testing makes sure that when the code is being created, it is created in small parts so that testing can be done quickly and effectively. It is easier to find bugs and errors in a small number of code lines than it is many code lines. Iterative testing ensures better productivity and management of issues and errors.

#### **6.2.2 White-box**

White-box method of testing requires the knowledge of internal structure of the system and programming skills. This method is done by software developers. Testing is applicable on low level of testing. White-box testing means structural testing.

##### **6.2.2.1 Find the test case that is going to break the code**

With White-Box testing, you have full access to the code, so you know what is happening in the code and therefore your test cases should try and include combinations that could produce unexpected results as the code / feature is not capable of handling the tests.

##### **6.2.2.2 Unit Testing**

Unit testing is testing a part of work that a developer has done and may or may not be complete. The concept is to test a unit of work that achieves some part of the solution. It may require the generation of stubs (code that is called that does not yet exist, so we

create stubs of code to allow for testing) or drivers (code that calls the unit of work that must be tested).

Unit testing ensures that the unit of code is fit for purpose and can be included into the next build, if appropriate.

### 6.2.3 Test Plan & Test Cases

Due to time restrictions, no formal test plan was put into place for the project. Instead the team worked on iterative testing, regression testing, unit testing and system testing.

Most of the testing that was done on the project was iterative testing, to ensure the code that was being delivered worked correctly. The developer of the code would do the initial unit testing (which would follow on from the iterative testing done during code generation) to ensure the code changes were correct, accurate and reflected the unit of work that was to be achieved. Once completed and the code was committed, all relevant systems would then be updated for the other members to test,

The remaining members of the team would then work on the system testing, regression testing and acceptance testing, to ensure that the whole module was working as per requirements and that the unit of code delivered, has not introduced issues or anomalies into the system.

Below is a sample test case table showing simple tests that could be conducted on the different parts of the application / solution. Normally this would be a summary sheet of actual tests to be carried out, where each test would be a single A4 page (or possibly pages), stating the test number, date of testing, testers name and id, what is being tested, pre-conditions needed for test, post conditions that should exist after test, the actual test case, how to perform the test case and what the results from the test case were (and if needed, the instructions on how to record the output of the test case).

**Table 4. Test Plan Template.**

Test Case	Description	Class	Input	Expected Result	Actual Result	Action
Case nbr	Description			What is result	What the result was	Next action, if any



Testing of code written by humans is an exacting task that has to take into consideration all stated objectives of the piece of code to be tested, but also needs to consider all unstated objectives, to ensure that all possible tests, both valid, invalid, possible, impossible and improbable, are correctly covered by the testing.

Due to this, it is necessary to decide how much must be tested to ensure optimal correctness and usability of any solution to be delivered. This is where a test plan will help to indicate which tests are needed and which are optional or of a lower value that any error encountered will not adversely affect the application or the users experience of the application, if these tests are not included.

### **6.3 Debugging**

The process of fixing the errors in the code by software developers. To prevent the system from behaving unexpectedly or even crash. Programmers can trace the program execution step-by -step and most of programming development environments provide a debugger for checking the code errors.

General the debugging process that team used during the project development:

- 1) Found an error
- 2) Trace it down using debugger tool
- 3) Fixed it
- 4) Run the project again to verify that it gives expected output

### **6.4 Implementation**

The Development Methodology that the group have decided to implement is the Sprint Agile development module, the reason, why is this methodology, because since the course have been started that development methodology has been constantly praised and this is, also, becoming the industry standard.

This has led to the further research and study the agile module over the previous years and to base the majority of the course projects around this method which has now become as second nature, this is the reason this development methodology was chosen to use for the final project.

Using this Methodology enables to do quick developments each week e.g. sprints, to show progress of the project, to test and verify what each member of the team is doing

and what requirement are needed, to keep the group focused on getting small bits done quickly so that the project proceeds and can be delivered in good time and to a high standard.

## 6.5 Accomplishments

In order to determine the success of the project, the following goals should be achieved:

1. The user can find the web site and learn vital information about the application.
2. A company can register with the site and can login.
3. The company can upload maps and select waypoints on a map.
4. The user can view company maps and waypoint/checkpoints on a browser.
5. The user can sideload the app onto a phone and use the maps and waypoint/checkpoint to get to a selected destination.

The Expected Deliverables Results, which are listed at the Table 3 below, must help for better evaluation and analysis of the whole project accomplishment level.

### 6.5.1 Expected Project Results

The expected deliverables for the project that were planned as follows:

**Table 5. Expected Deliverables.**

Working website	
Delivery	Done
User can find and use the web site	✓
Companies can register for use of the website	✓
Companies can log into the site, update their information, map and way points and logout	✓
Anybody can send on a query regarding the site and application	✓
Hosted Database	
Storage of company data	✓

Storage of maps	✓
Storage of waypoints	✓
Android Application	
Launch screen	✓
Ability to capture where the user is (Barcodes, QR Codes)	✓
Show maps and places user can navigate to	✓
List of instructions / steps on how to get to the destination	✓

## 7 Critical analysis

### 7.1 Achievements against the original objectives

The baseline for the project was to have;

- A web site (hosted on a web platform) to allow users to find out about the solution provided and to allow users and businesses to contact us.
- For businesses to be able to register interest in our solutions via the web page, to be able to update / change and/or add information to the data in the database.
- A backend hosted on a providers site, to allow for demonstrate of the solution.
- An android application (side-loaded) that could be used on any android phone, to allow a user to find their way from where they are to a specific destination

The original concept and design called for Bluetooth beacons and NFC Tags to be used but it was understood from the outset that unless approval for the purchase of these items was granted, then they would not be included into our project. By the time approval was granted and the purchase put through, there was insufficient time to develop the necessary code to support these features.

There was speculation at first, of showing an image to the user of the building / area and the path that had been selected for the user but considering how much other work the team had to do, this was considered as an optional extra.

As such, the Web Site, Database and Android App have not veered too far from the original objectives that were set out for the project.

## **7.2 Difficulties encountered**

The project was based on an idea without consideration of the technology that would have to be used. Due to this, there was a lot of extra research and external education, that had to be done prior to the project starting off. Documentation for the timeline of the project did not take into consideration any of this extra work and that put extra pressure on the project team, due to less time being available to work on designated tasks.

The extra learning was not just from the Technology that would be used within our solution, but also in the technology we would be using to build our solution.

Eclipse was the selected IDE (Integrated Development Environment) which was new to the Team, but this was selected for its ability to integrate with other resources that would be used.

GITHUB was selected as the repository that would be used for the storage and ability to share the code and documentation that would be generated during the project.

Azure was the solution for the hosting of the project web site.

All the above noted technologies were never used by the Team before and all necessitated a learning curve that included a lot of difficulties and issues for the Team members

## **7.3 Lessons learned**

Working on a major project needs a lot more time at the start to figure out exactly what has to be delivered and to make sure that the deliverables are well documented and formalised, so that the project does not 'drift' from the original requirements.

Due to the small team size, it is more appropriate for all to work on the solution, in all aspects, and in all areas as otherwise there is the possibility of one Team Member being responsible for too much of the work. This can cause serious problems / issues for other

team members, when they need to work on project areas, as they may not have all the knowledge needed due to lack of participation when the work was being done, on the area they now need to contribute to.

Projects of this size and magnitude, need to be carefully monitored from the start and milestones, need to be checked regularly, to ensure that the education of team members, the deliverables from those team members, are all achievable. If constant monitoring is not in place, then the project may not be completed in the original order specified or to the original requirements.

#### **7.4 Project follow the planned timeline.**

Though considerable time was spent in working out a timeline for the project, due to the method of work allocation, the timeline was more of a goal achievement rather than a “must have this done by” timeline.

Due to the work assignment and how tasks were managed, the timeline was adhered to in the starting of tasks but not in the completion of tasks, as a lot of the tasks could be carried out that the same time.

The key elements of the project were completed to an initial state and followed the timeline, but the completion of the tasks took longer and therefore were not following the timeline.

The timeline did assist with getting the tasks started on time, but it was the deadline date that drove most of the task’s completion state.

#### **7.5 Timeline usefulness**

The timeline is what is used by most organisations to determine if a project will meet its defined end date.

All tasks are assigned a start / end date with a duration to allow for the code to be delivered with at least basic unit testing completed. It is that timeline, where employee’s time is booked against, that will determine if a task will meet its due date and if not, the timeline will then show what repercussions exist, if any. It is possible for certain tasks to run over their due date without affecting the end date of the project, but this is not always the case.

Within the project, the timeline was of a basic nature that included tasks that were intended to be done, if resourcing the necessary hardware, was successful. As previously stated, part of our project was under doubt as to whether the hardware could be purchased and delivered on time. The timeline did not take this into consideration.

## **7.6 Key findings to help to work on the project**

Projects by their very nature normally have a manager and team assignment. For this project, the Team took on the manager role but this has been known to lead to a lack of control and resources are then not managed as efficiently as required.

Documentation and fixed, non-changeable goals, as well as adherence to the project plan, documentation of any divergence encountered or any goal missing its due date, is the responsibility of the manager. If any issues are encountered, then meetings are needed to address those issues so that action plans, achievement goals and timelines can be updated accordingly.

If all members of the team have predefined roles that do not change for the duration of the project, then it is more than likely that the project could be delivered, on time, provided that the correct members of the team are in the correct roles.

Once a member has been assigned a role, then the tasks assigned to that role become the responsibility of the manager and the member, to ensure that they are started on time, completed on time, and for any issue or delay, to be notified immediately to the manager so that the project team can then discuss and action a coordinated plan, that can reduce or remove the issue / delay.

Due to the nature of our project and the controls placed upon the project, by external factors, the above was not possible and this then did have effect on the project.

Tasks must be assigned out in such a way that all the team are working on the project and not just a part of the team. The Team shoulders the responsibility for the delivery of the project and not an individual or part of the team. Teamwork is essential in making sure the project starts off correctly, runs smoothly and is completed, in full, by the intended due date.

Due to the way the project was managed, tasks were not assigned out so that the team worked in unison and this did also have an non-positive impact on the team, as it was a

reduced functional team instead of a coherent integrated team with one drive for the completion of a above high standard solution.

## **8 Conclusions**

Many learnings can be derived from the project as it now approaches its completion date. Some of these are discussed below but there are many more, as each decision made, choice taken, or direction followed can be considered as either a positive or negative factor in the success of the project.

The initial goal of the project was “seen” as a simple route-finding problem that could be extended out to many different types of issues that could be addressed. From finding your way from where you are to a specific destination within a building, to a solution to allow a user to find a simple walking route through the forest, to hill climbing trails, to even the route though public / private fairs.

Included in this would be the ability to extract extra information from the chosen path, within the app, allowing the user more information on where they are, what is about them and what they can do next.

The initial plan and documentation did consider some of the above but as noted previously, the Team never took into account the amount of learning that was needed, the time needed for that learning and then applying that learning in such a way, as to resolve the work that was needed for our proposed solution.

Each time a team member must learn something new, then time is actually lost on the project as that member must first research what is needed, select an appropriate solution, read / view the appropriate material on how to implement that solution and then finally, take what has been learned and apply that to the project in such a way, as to resolve the item of work, so that a correct solution is then provided to the project.

The project called for numerous forms of technology that have not been used by the team previously, all these technologies needed to be researched in how to write the necessary code and then to use that code within the project.

From how to scan a QR code and incidentally, the same code can be utilised for scanning barcodes, to integrate this into the Project, and then apply that same formula of learning

and applying that learning in the areas of Client / Server communication, image storage within a database, communication between the app and the database, etc.

Within the above, there was also the learning curve needed to use the new applications / packages that the project needed. Eclipse for the development of the web server and client pages, Android Studio for the development of the app, GITHUB for the storage and sharing of all the code and documentation, not to mention the external sites needed for the hosting of the web site and database.

To learn numerous new technologies, to find and use many different solutions, in the development of a single project, while working on numerous other tasks at the same time, and delivering on the project at the due date, shows a Team that is capable of delivering what is needed, when it is needed, with the ability to conquer challenges and take on new abilities to deliver the required solution.

The project has been a stressful period of development for the team and when external influences are taken into account, whereby team members were externally influenced in a negative way, impacting on the project deliverables, for the team to still be able to function as a unit and generate the required ability, energy and focus to complete the project, shows a level of competence, integrity and aptitude needed when working under stressful conditions.

In conclusion;

- The Team is still working together as a functional unit and delivering on the project
- The Project is being completed on time and will be delivered as per requirements

And as such, we can consider the project to be completed on time, missing some functionality (Bluetooth beacons and NFC Tags) which, due to the necessary involvement of the college procurement, could not be depended upon to arrive on time or on schedule.

There is a working solution available, but some further changes could be added to enhance the business side of the solution (upload of way points from pre-defined file formats as opposed to manual inputting the information). The user side of the solution



could be enhanced to support active route imagery, update of maps to show where the user has come from, where the user is and where the user is going. To automatically change the map to the correct floor when the user moves to a different floor and other such nice animations and transitions.

Any project, no matter how complete, can always have more functionality added in, the main issue with this, is knowing when to stop and leave what has been created, alone, to do the job it was created to do.

## 9 Bibliography

Web sources were used to design, develop and test the project, all references are listed in the next chapter.

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## 11 Appendices

### 11.1 Appendix A

The Gantt Chart in full.

ID	Task Mode	Task Name	Duration	Start	Finish	Prede	Assigned
1		<b>Phase 1</b>	<b>5 days</b>	<b>Mon 09/09/19</b>	<b>Sun 15/09/19</b>		
2		Initial Proposal	5 days	Mon 09/09/19	Fri 13/09/19		Kevin,Kate,Chris
3		One page initial proposal submitted to Moodle by 15 Sept	0 days	Sun 15/09/19	Sun 15/09/19	2	Chris
4		<b>Phase 2</b>	<b>33 days</b>	<b>Mon 16/09/19</b>	<b>Thu 31/10/19</b>		
5		Technical Proposal	25 days	Mon 16/09/19	Fri 18/10/19	2	Chris,Kevin,Kate
6		Project Proposal document submitted to Moodle by 21Oct	0 days	Mon 21/10/19	Mon 21/10/19	5	Chris
7		Project Presentation	0.5 hrs	Tue 22/10/19	Tue 22/10/19	6	Kevin,Kate,Chris
8		Literature Review	33 days	Mon 16/09/19	Wed 30/10/19	3	Kevin,Kate,Chris
9		Literature Review document submitted to Moodle by 31Oc	0 days	Thu 31/10/19	Thu 31/10/19	3,8	Chris
10		<b>Phase 3</b>	<b>67 days?</b>	<b>Thu 31/10/19</b>	<b>Fri 31/01/20</b>		
11		All code to beuploaded to Moodle by 10am on 30th Jan.	66 days?	Fri 01/11/19	Fri 31/01/20	9	Chris
12		<b>Database Design</b>	<b>6 days</b>	<b>Fri 01/11/19</b>	<b>Fri 08/11/19</b>	<b>9</b>	
13		Database Selection and initial design	1 day	Thu 31/10/19	Thu 31/10/19	9	Kevin
14		ERD of Database	1 day	Fri 01/11/19	Fri 01/11/19	13	Kevin
15		Implementation of database	2 days	Mon 04/11/19	Tue 05/11/19	14	Kevin
16		Hosted Site - Implementation	2 days	Wed 06/11/19	Thu 07/11/19	15	Kevin
17		<b>User - Website design</b>	<b>11 days</b>	<b>Fri 01/11/19</b>	<b>Fri 15/11/19</b>	<b>12SS</b>	
18		Initial Design	2 days	Fri 01/11/19	Mon 04/11/19	9	Kate

Figure 13. Phase 1, 2 and 3 features.

ID	Task Mode	Task Name	Duration	Start	Finish	Prede	Assigned
19		Landing Page	0.5 days	Tue 05/11/19	Tue 05/11/19	18	Kate
20		About us page	0.5 days	Tue 05/11/19	Tue 05/11/19	19	Kate
21		Contact Us page	2 days	Wed 06/11/19	Thu 07/11/19	15	Kate
22		Registration page	1 day	Fri 08/11/19	Fri 08/11/19	21	Kate
23		Organisation - Login and Verify	2 days	Mon 11/11/19	Tue 12/11/19	22	Kate
24		Organisation - view details	1 day	Wed 13/11/19	Wed 13/11/19	23	Kate
25		Organisation - update details	2 days	Thu 14/11/19	Fri 15/11/19	24	Kate
26		<b>Application - Map</b>	<b>26 days</b>	<b>Fri 01/11/19</b>	<b>Fri 06/12/19</b>	<b>9</b>	
27		Launch screen	1 day	Thu 31/10/19	Thu 31/10/19	9	Chris
28		Ability to get buletooth info	5 days	Fri 01/11/19	Thu 07/11/19	27	Chris
29		Ability to get NFC info	5 days	Fri 08/11/19	Thu 14/11/19	28	Chris
30		Ability to get BarCodes info	5 days	Fri 15/11/19	Thu 21/11/19	29	Chris
31		Ability to get QR codes info	5 days	Fri 22/11/19	Thu 28/11/19	30	Chris
32		Link to database - download map and locations	5 days	Fri 29/11/19	Thu 05/12/19	31	
33		<b>Application - Map Marker</b>	<b>10 days</b>	<b>Fri 06/12/19</b>	<b>Thu 19/12/19</b>	<b>33</b>	
34		Icon on map and drop-down of destinations	3 days	Fri 06/12/19	Tue 10/12/19	32	Kate,Chris
35		Marker to display current location	1 day	Wed 11/12/19	Wed 11/12/19	34	Kevin
36		Potentially track user location	6 days	Thu 12/12/19	Thu 19/12/19	35	Chris
37		<b>Application - Detect Beacons</b>	<b>10 days?</b>	<b>Fri 20/12/19</b>	<b>Thu 02/01/20</b>	<b>33</b>	
38		Detect location by Bluetooth	2 days	Fri 20/12/19	Mon 23/12/19	36	Chris
39		Detect location by NFC	2 days	Tue 24/12/19	Wed 25/12/19	38	Chris

Figure 14. The Phase 3 functions and their breakdowns.

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Assigned
40		Detect location by QR	2 days	Thu 26/12/19	Fri 27/12/19	39	Chris
41		Detect location by BarCodes	2 days	Mon 30/12/19	Tue 31/12/19	40	Kate
42		Inform user when destination is reached	2 days	Wed 01/01/20	Thu 02/01/20	41	Kevin
43		<b>Application - Route Instructions</b>	<b>10 days?</b>	<b>Fri 03/01/20</b>	<b>Thu 16/01/20</b>	<b>37</b>	
44		Display path	2.5 days	Fri 03/01/20	Tue 07/01/20	42	Chris
45		Keep track of current progress	2.5 days	Tue 07/01/20	Thu 09/01/20	44	Kevin
46		Send user new instruction when milestone reached	2.5 days	Fri 10/01/20	Tue 14/01/20	45	Kate
47		Notify user when destination reached	2.5 days	Tue 14/01/20	Thu 16/01/20	46	Chris
48		Testing and documentation phase	11 days	Fri 17/01/20	Fri 31/01/20		
49		<b>Phase 4</b>	<b>7 days</b>	<b>Sat 01/02/20</b>	<b>Tue 11/02/20</b>		
50		e-copy of documentation to be uploaded to Moodle by 4pm	0 days	Sat 01/02/20	Sat 01/02/20	9	Chris
51		Two bound printed copies of the documentation to be handed into Paula Briody, IT Office, by 4pm	0 days	Tue 04/02/20	Tue 04/02/20	50	Kevin
52		Demonstration and presentations will be held on week of 11th February	0 days	Tue 11/02/20	Tue 11/02/20	51	Chris,Kate,Kevin
53							
54							
55							
56							
57							

Figure 15. Phase 3 and 4 breakdown and final deadlines.

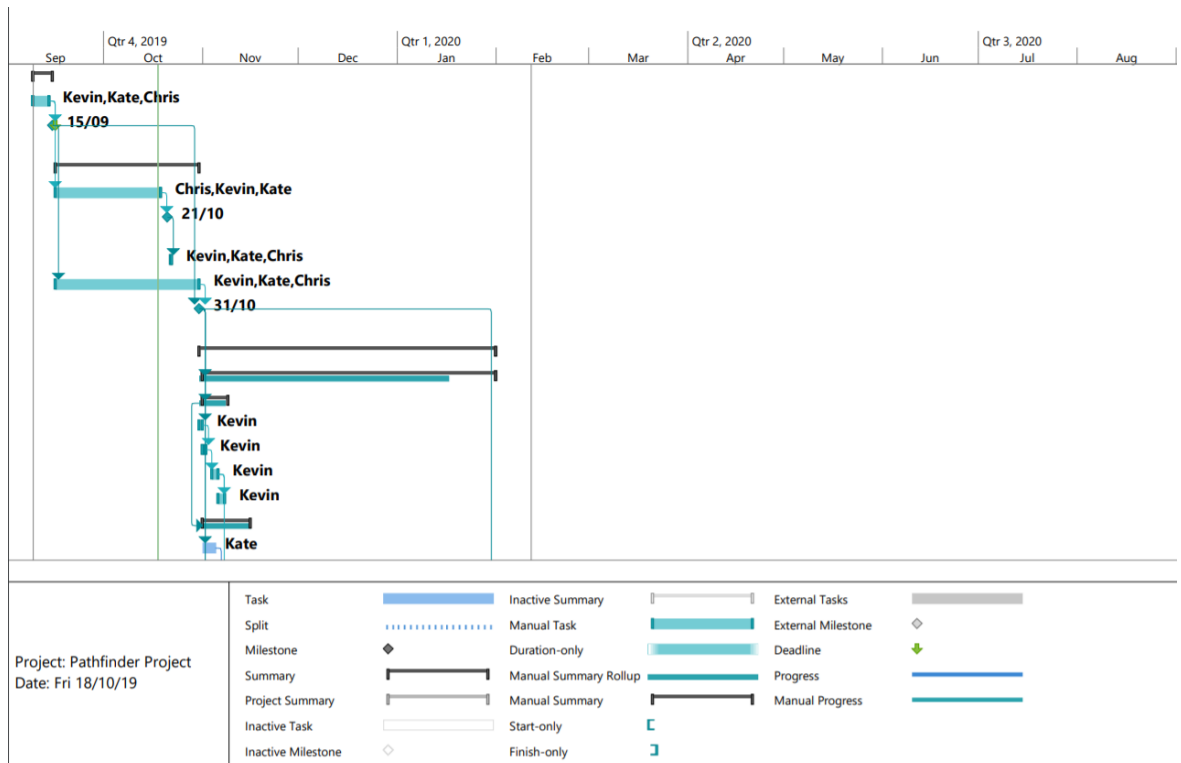


Figure 16. Visual representation of our schedule deadlines.

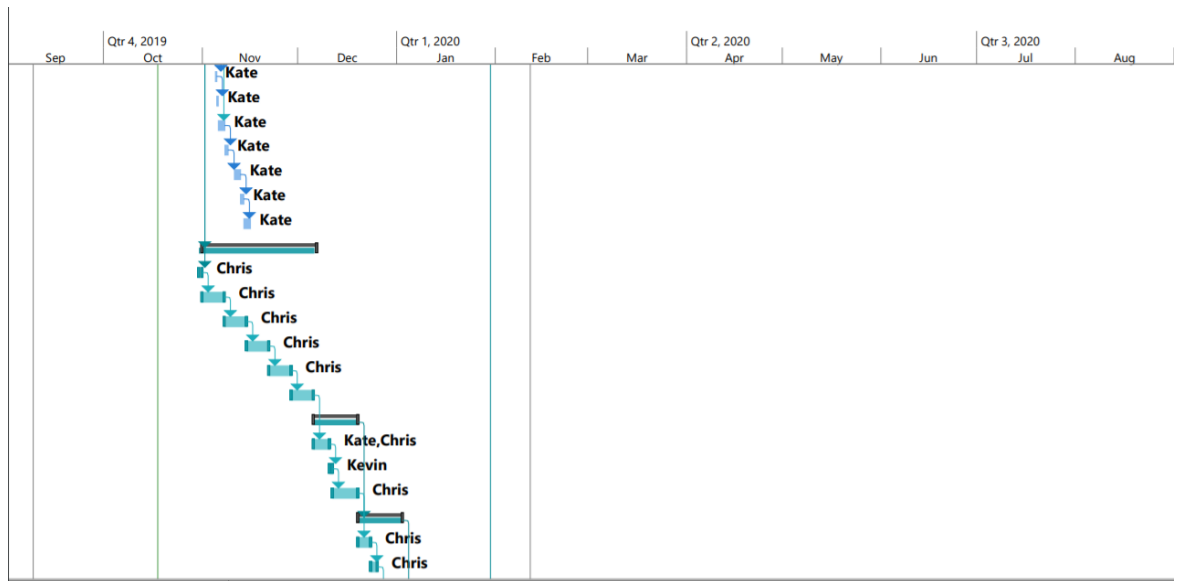


Figure 17. Visual representation of our schedule deadlines 2.

## 11.2 Appendix B

This is our excel spreadsheet with the features breakdown including sprints

Feature	Database - design	User - Website	Application - Map	Application - Map	Application - Detect Beacons	Application - route Instructions
Storyboard	Design a website that displays information about the application and menus for the different aspects	User can view website and allows organisations to login and update their information				
Sprint 1	Database selection and initial design	Organisations send in registration request - used to create organisation in database	Present landing screen to user			
Sprint 2	ERD of Database	Landing page and option to allow organisation to sign in	Read in the Organisations Code to download data to the application			
Sprint 3	Implementation of database in SQL	Organisation view their details and can upload their maps	To show the map after download of data and option to select where the user would like to go.			
Sprint 4	Hosted site - implementation of database onto site	Organisation can upload/update information for navigation to work		Marker to display where your current location is		Show list of steps to get from where you are to where you are going
Sprint 5				Potentially Track User location	Detect where you are by using bluetooth beacons	
Sprint 6					Detect where you are by using NFC	
Sprint 7					Detect where you are by using QR Codes	
Sprint 8					Detect where you are by using Bar Codes	

Figure 18. Feature Breakdown including Sprints.

This is our full feature breakdown structure.

User - Website		Hours	Assigned to	Database - Design		Hours	Assigned to
User can view website and allows organisations to login and update their information				Design Database to handle website data and application data			
Landing page and option to allow organisation to sign in			Kate	Database selection and initial design			Kate,Chris,Kevin
	Design and build landing page		Kate	ERD of Database			Kate,Chris,Kevin
	User login and verify		Kevin	Implementation of database in SQL			Kevin
	user login screen		Kate	Hosted site - implementation of database onto site			Kevin
	user database		Kevin	Connectivity testing (web site / app)			
	Organisation view their details and can		Chris				
	Organisation can upload/update		Chris				

**Figure 19. Part 1 of the FBS.**

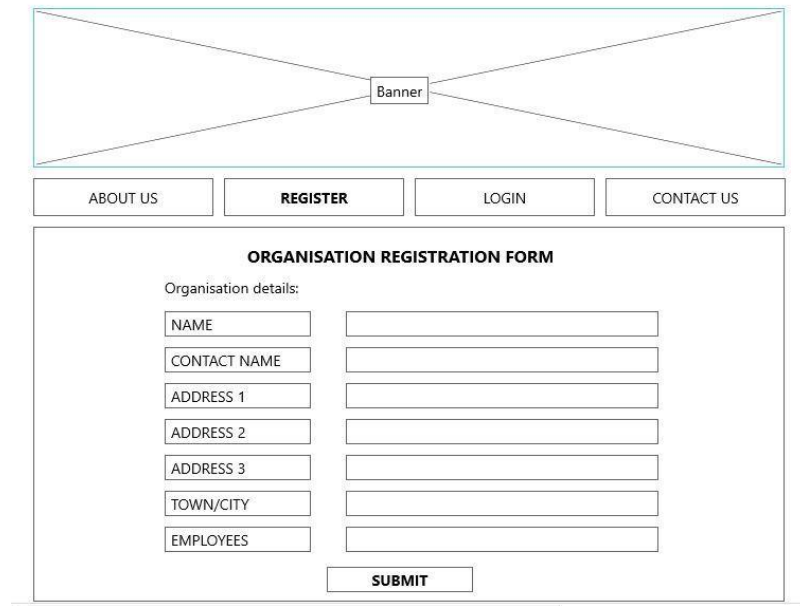
Application - Map		Hours	Assigned to	Application - Map Marker		Hours	Assigned to
The map will display a 2d version of the building				The map will display a icon that the user will click or a dropdown-menu where all locations on the map are listed			
Present landing screen to user with information about the using the application			Chris	Display Icon on map or use drop down menu where all locations are listed			Kevin
Launch screen up and running and passing onto main screen. Basic instructions on how to use the Ability to grab input from Bluetooth			Chris	Marker to display where your current location is			Chris
Ability to grab input from NFC			Kevin	Potentially Track User location			Kate
Ability to grab input from Barcode			Kate				
Ability to grab input from QR Codes			Kevin				
Link to database, download map and location			Chris				

**Figure 20. Part 2 of the FBS.**

Application - Detect Beacons		Hours	Assigned to	Application - Route Instructions		Hours	Assigned to
User will be constantly detected using bluetooth beacon or will only be detected when reached a milestone				the user will be shown a path using a real time icon or a series of steps during each milestone			
Detect where you are by using bluetooth beacons			Chris	Display Path using shorted route algorithm			Chris
Detect where you are by using NFC			Kate	keep track of the users current progress on path			Kate
Detect where you are by using QR Codes			Kevin	Send user new instructions when milestone reached			Kevin
Detect where you are by using Bar Codes			Kevin	Notify user when destination reached			Kevin
when user has reached a destination the nfc tag will send information to the user			Kate				

**Figure 21. Part 3 of the FBS.**

## 11.3 Appendix C

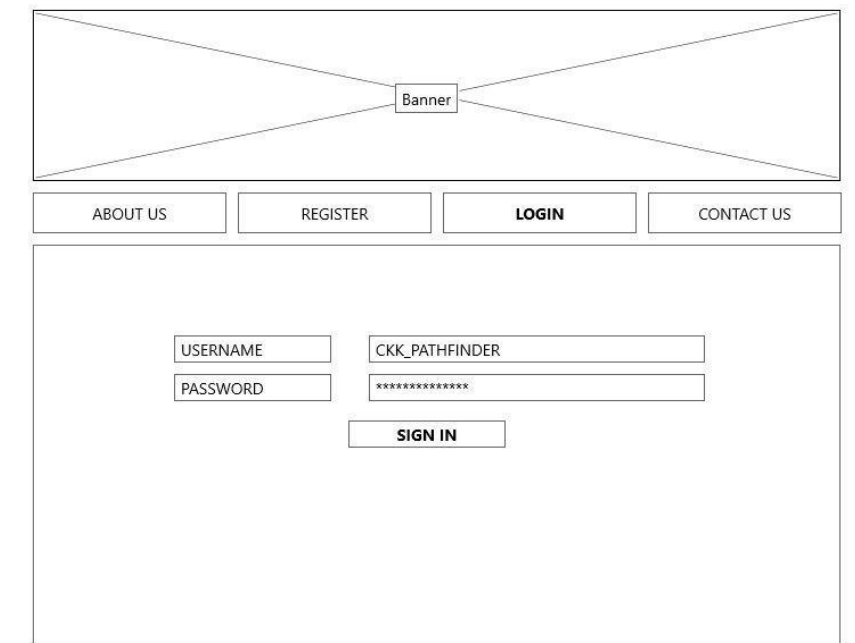


The registration page features a banner at the top, a navigation bar with 'ABOUT US', 'REGISTER', 'LOGIN', and 'CONTACT US', and a main form titled 'ORGANISATION REGISTRATION FORM'. The form includes fields for 'NAME', 'CONTACT NAME', 'ADDRESS 1', 'ADDRESS 2', 'ADDRESS 3', 'TOWN/CITY', and 'EMPLOYEES', followed by a 'SUBMIT' button.

ORGANISATION REGISTRATION FORM	
Organisation details:	
NAME	
CONTACT NAME	
ADDRESS 1	
ADDRESS 2	
ADDRESS 3	
TOWN/CITY	
EMPLOYEES	
SUBMIT	

Figure 22. Registration Page.

This is the web page that the organization must fill up and submit to the creators of the application so that their organization is registered and can then use our application.



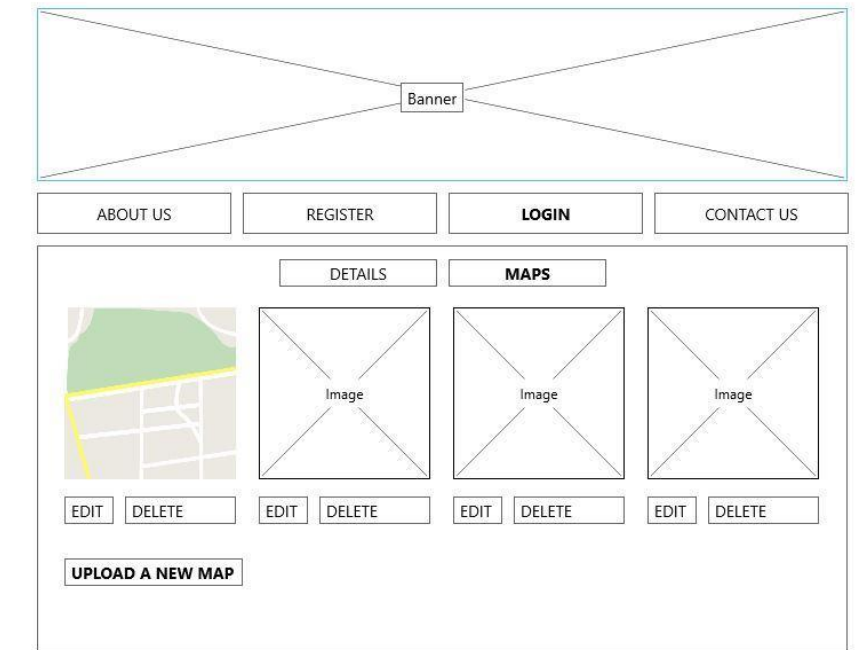
The login page features a banner at the top, a navigation bar with 'ABOUT US', 'REGISTER', 'LOGIN', and 'CONTACT US', and a main form with fields for 'USERNAME', 'CKK\_PATHFINDER', and 'PASSWORD', followed by a 'SIGN IN' button.

USERNAME	CKK_PATHFINDER
PASSWORD	*****
SIGN IN	

Figure 23. Login Page.

The login web page for the organization/user.





**Figure 24. Maps uploading page.**

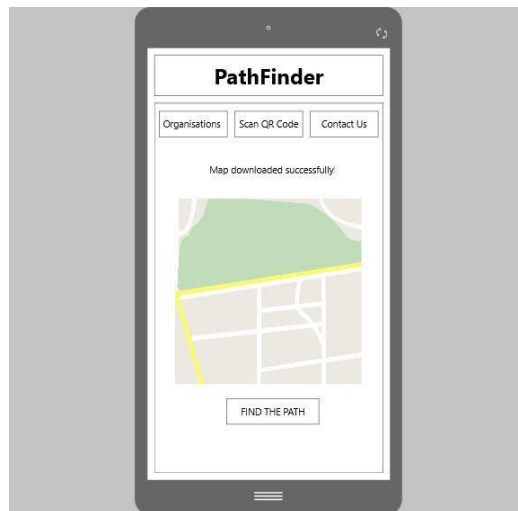
This is the Maps section of our website which allows the organization to upload/edit and delete their maps.

## 11.4 Appendix D



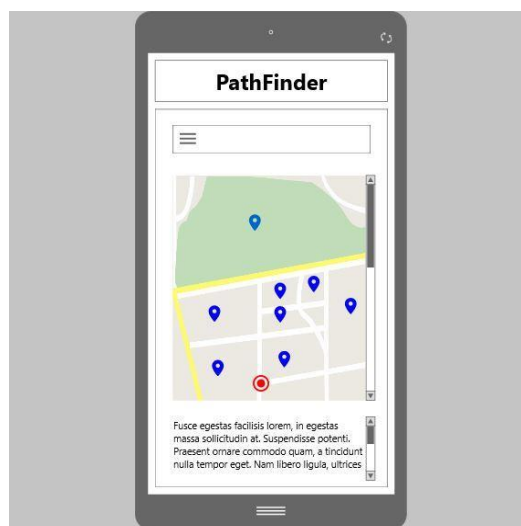
**Figure 25. Android application QR codes scanner.**

This will be the layout of the application when it needs to scan a QR code to find out the current location inside a building.



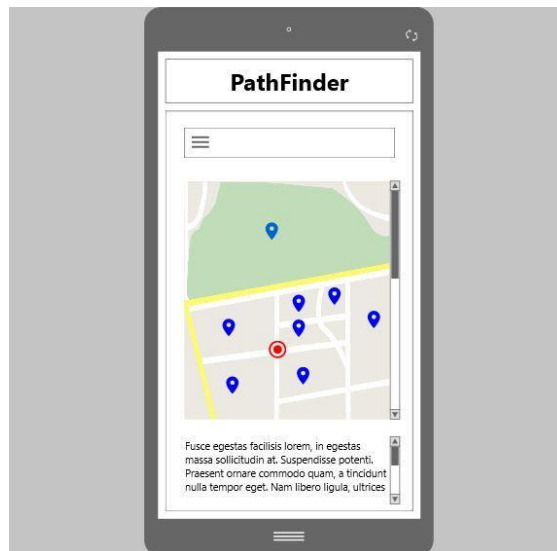
**Figure 26. Downloading maps after scan.**

This is the layout when a map has been successfully downloaded from our database and displayed to the user.



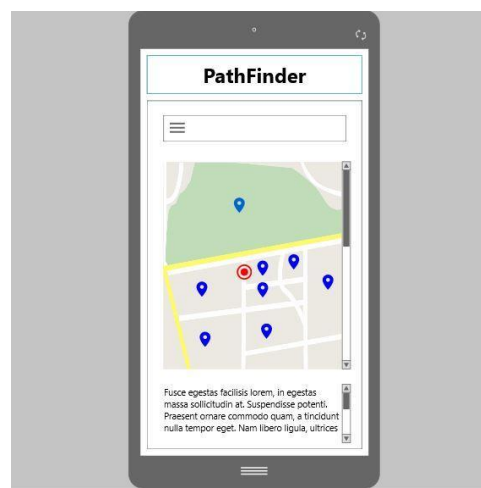
**Figure 27. Route display.**

This is the map of a building with different points on the map that the user can select.



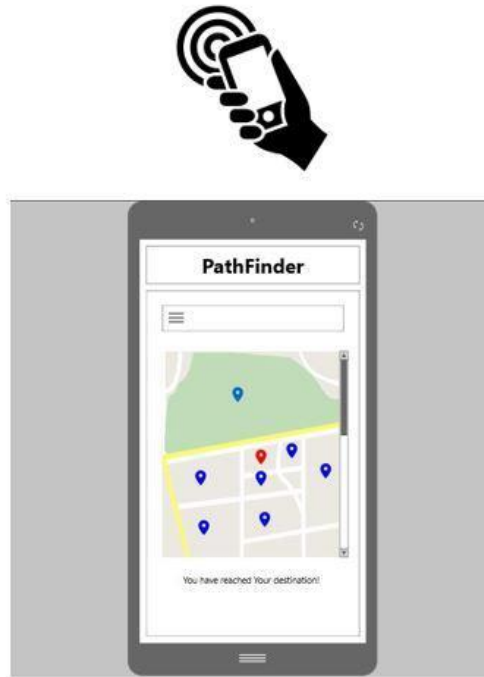
**Figure 28. Moving at this route.**

This is the map being updated with the user's current location.



**Figure 29. Moving to destination.**

This is a display of the user's current location.



**Figure 30. Reaching the destination.**

This is the display on the map when the User has reached their current destination.

## **11.5 Student 1 Reflection: Kevin Dunne (K00232599)**

### **11.5.1 Introduction**

This is my personal journal of all the contributions I made during our Third Year Project “PathFinder” and all the problems that happened during it, this also contains my conclusion on what it was like to work on a project this intense and working with my teammates and what I learned and achieved during this entire project.

### **11.5.2 My Contribution**

The first thing we did as a group was to decide what our project was going to be, Chris brought up an idea of people getting lost inside buildings such as hospitals and this really stood out to me because I have personally gotten lost in Waterford hospital multiple times and made me realise the incredible value that a project like this has, we then decided to based our project on this idea using barcodes codes, NFC chips and Bluetooth beacons as are hardware/way of navigation.

I needed to help to prepare our project proposal document which was due on the 15th of September.

The next thing we did was to decide on our roles for our meetings and what each of us would do and so on, Chris was chosen to be the chairperson and Kate is the scribe, we also decided that we would alternate different roles so everyone gets a chance at each which I really liked.

The next thing I did was do my research for our technical document, I covered the methodology, project scope and schedule.

I worked together with my team to develop an feature breakdown list which broke down the main points that we as a team needed to get done and we also worked out the components of each of the main points, I helped fill out the information in the FBS to give a better description of each of the main points we needed to get done and I also assigned roles to each member of the team and a template manhour and due date on each of them.

My team worked together and helped develop our Gannt chart which we needed for our technical document, I then had to personally go over and correct all minor mistakes.

I researched the literature review document subjects which will be the topics that I will have to cover when I start the literature review, I covered the introduction, pre-existing technologies, upcoming technologies, web hosting and parts of the conclusion.

I created basic web pages on NetBeans's and ran into some problems with connecting to a SQL database locally because of an update during the summer it took a bit of research to solve this.

I started to study Microsoft Azure which was a cloud computing application and the different applications that I could use for our project such as hosting websites, database and database servers, my research was needed for our literature document and also how to actually use the different applications available to me.

Microsoft Azure was one of the largest learning curves in this project because it was such a new technology to me and it required me to spend hours learning the basic things which were so essential to our project, one of the first things I learned how to do was to create a resource group on Azure, this was one of the most fundamental things because it grouped everything under its umbrella such as the Website, Database, storage and Blob storage.

The next step was to go ahead and create the actual website, this caused me no end of grief because all the video examples I learned from used PHP, .Net or other languages

instead of java and it took me nearly 1 week to figure out how to exactly to create a website that is built using Java, I had to go through a variety of different failed attempts using other frameworks before I actually figured out what to do and once I did this I was able to create a website called “<https://pathsearcher.azurewebsites.net/>” was forced to use the name pathsearcher instead of PathFinder because it wasn’t available.

I studied how to upload a website to Azure using NetBeans and after I tried and failed to upload a test website using the NetBeans application which caused me significant problem’s because of the lack of any useful plugins which could help me connect to Azure, this set me back significantly and caused me a lot of stress and I needed to research in depth if it was even possible using NetBeans and this made me rethink what tools we as a group were going to use for our project.

I studied how to create a database on Microsoft Azure and how to connect to it to this database using NetBeans but because of the lack of plugins I had to abandon this and after some research I realised I needed to use visual studios which has extremely helpful integrated support for Azure but because I had not used visual studio in year’s this caused me to have to spend hours researching just to understand the basics again, I

I did more in depth research about Azure SQL database and realised that MySQL and MS SQL were quite different but I still attempted to create an azure hosted database using the Microsoft server management tool along with visual studios MS SQL, I realised that the learning curve to figure out how to work these technologies and how to use MS SQL was to large of a learning curve so I abandoned using these technologies and instead looked for some alternatives.

I realised that I couldn’t continue to try and use NetBeans’s as my main IDE because of its lack of support for azure and so I started looking into alternatives and one of the alternatives was eclipse which Natasha Kiely introduced to us in class and although it was quite difficult to use at first, I realised it was actually an extremely powerful tool and it had a lot of support when it came to apache tomcat and Azure plugins both very important tools that I needed for publishing a website and also testing by using a local database.

I learned how to use Eclipse to publish a website to Azure and researched how to import my NetBeans project into eclipse so I didn’t have to recreate anything, this cost me a considerable amount of manhours but it was worth it because of the benefits eclipse offered.

During my teams weekly meeting it was decided that we would switch roles, so I became the chairperson, Kate became an attendee and Chris became a scribe.

I finally managed to publish the first iteration of our website to Azure but I needed to download two important plugins such as apache tomcat and azure, once I did this I was easily able to upload our website by using my student account details in conjunction with the azure plugin.

I setup a hosted database on Remote MySQL instead of using azure because the azure needed to be done in SQL which I wasn't familiar with and the migration tools I tried to use in conjunction with MySQL workbench gave me a lot of problems so I moved our SQL database to a cheap alternative with the intention of switching back when I have more time to study the Azure SQL database application in more detail.

I created the first iteration of our MySQL ERD diagram, I created users, status and maps tables with some basic data for testing.

I updated the pathsearcher website to have 4 simple pages which are an index, register, login and contact us html page, I also setup the back-end servlets to handle the register and login control.

I updated our ERD SQL diagram with another iteration that had some columns changed around to make our database more sensible.

I worked with Kate to update our websites design and one she had recreated a new look for our website I uploaded it to Azure, and I added some extra servlets to handle more interaction for our website such as some controls which let us view the organisations and users details that a logged in user can view.

I created a maps.jsp page which has 4 links to upload an image, display an image which you select from a dropdown an add points link and a viewpoints link, this was one of the most challenging aspects of the project because I did not do a lot of JSP before this project and was very inexperienced in how to go about getting this page to do exactly what I wanted it to do, this specific page needed me to invest a significant amount of man hours because it was a very essential part of our project.

I was able to create the maps.jsp in such a way that it could upload an image and store it into our database and then be given a dropdown list of all the images that users

organisation has access to this was quite a significant leap forward because our android application also needed to be able to do this.

I added new tables to our ERD Diagram to store both the map points and the points those map point lead to which is the most important part of our entire SQL database, I then implemented servlets to handle the users input of these varies values and then to store them into the database, this was a challenge because my first iteration of the layout to achieve this is not user friendly, I will go back and redo the overall layout in time to create a more user friendly interface but for now I have just been creating the points in a SQL document and manually adding it to the remote database.

I created a very simple android application that has a simple splash screen and menu activity, I had planned to use this as a template but Kate had recreated the android application in a more stylish way such as having animations and a more friendly user interface, I then abandoned my version and continued to use hers.

I setup a ActionJson servlet that acted as a RESTful API web service which I Intended to use as the method of transferring the tables Map\_Points and the Point\_to database table information to the android application, this at first caused me extreme amount of trouble because I had basically zero experience with JSON and I needed to invest a lot of manhours into just learning exactly how to use JSON, once I had the basic understanding of how to work with JSON I created a special Node class which I used with multiple Array Lists to handle my database information and I used these Array Lists to create a nested JSON Array inside a JSON object.

This caused me a lot of problems because of my experience with JSON I was not formatting the JSON in an acceptable format, this required a lot of trial and error to correct and needed me to attempt many iterations to clean up the JSON format and to stop the servlet from continuing to store data inside the JSON object every time the web service was called.

I also created another RESTful web service called ActionJsonOrg which handled all data dealing with the organisations details and the map details database table information, because of my experience with the first one this one was a lot more simpler and quicker but also more tricky in other ways because I was transferring images in blob format which were difficult to reconstruct on the android application but I succeeded.



I created multiple new activities on the android application such as GetMapActivity, GetOrgActivity which handled pulling the information from the REST web services onto the android application.

I created a PathFinder Activity and a DisplayActivity which handled the user selecting the paths from two dropdown menus and also giving the option to the user to scan a QR code to get their current location, Kate had developed the QR code scanner so I only needed to integrate it into the application in my desired way, the Display Activity displayed the actual Maps the Organization specified building has and the Path information that the User needed to follow to actually reach his destination.

I worked together with Chris to integrate my Dijkstra's Algorithm that I had done for Eugene Kenny's Assignment to find the shortest path in a directed graph, I had managed to integrate the algorithm into our Display Activity page and Chris worked on how to only return the path information from the shortest path which I could then use to display to the user in a more human readable fashion by listing all the Point Names the user has to follow a lot with the direction which were done in a simple fashion.

I had how our REST web service ActionJson handled its database insertion because of the way my Dijkstra's algorithm is setup it can only read points in a certain fashion such as 1-N which was problematic because the information that is inserted into the database could be random numbers such as 100,30 and 50 etc, this presented a problem for me because it would cause our program to crash because it would job to an index that doesn't exist, I solved this by creating 2 for loops to convert the old Values which were stored in An Array List and then changing the Values in my MapPoint and Special Points array list to use the values from 1-N this meant that a Number such as 13 which is at index 1 would convert every matching value in the other arrays into value 1, this solved my problem.

I restructured the entire android application to create a better user experience, such as what the user next to update first and I created instructions and redo all the design to tidy up the thrown together design I have been using previously.

I worked on the Configuration part of our project document, which dealt with all the technologies I used and how I used them.

### **11.5.3 Problem/Team Theory**

This project has helped me to better understand the incredible research aspect involved in projects of this magnitude, I have personally had to research a variety of different things such as Azure, database hosting, Android Studio and a variety of different programming implementations.

The intense amount of research that our project had to undertake cost me a lot of time and it was especially difficult because of some of the technology we were introduced to I had no experience with and so everything relied on me doing the research with depending on what field could take as little as a day or as long as a month which was very problematic for me because of the variety of projects I had running concurrently, the team decided to split up some of the research responsibility which meant I focused on the technologies, Kate focused on QR Codes and Bar Codes and Chris focused on NF chips and Bluetooth devices, this solved an issue of mine and took some of the pressure off me.

The Azure and Android Studio applications were very problematic tools because both required our team to learn so an intense amount of information especially Azure which required some much obscure research to work the way we needed it to, Android Studio was very difficult to use because it introduced to us just this semester and it had a lot of important functions that all needed to work in conjunction with each other and this caused a lot of integration issues, so we as a team decided to teach and demonstrate different to each other our solutions to in class practical's to speed up the learning process and take the pressure off each other.

The biggest problem that has hounded our project since the beginning has been time and time management, This has been my first big team project where I have been placed under such intense time pressure and where both my team members have also been under massive time pressure because of real-life situations and this has placed tremendous pressure on my shoulders to help keep our team update to date and constantly moving forward in different aspects of our project.

This has led me to abandon a lot of the variety of functions I had intended to implement in both our project website and our android project itself and instead focus on the core aspects of our project so as getting the database up and running and the website, creating the point and then creating a web service so the android application can use them and

then setting up the android application to actually find the optimal path which is the basis of my project.

I have been able to implement all these functions into my project, but they are not up to the exceptional standard I had set fourth for myself and this has greatly disappointed me and I felt it has affected the overall standard I have maintained throughout my college years.

#### **11.5.4 Conclusion**

I have learned a lot by working in a project of this magnitude and it has helped me to be better able to management both my time and what I need to prioritize to actually achieve my desired project goals, I believe that if I was to redo this project from the start the difference between what I could achieve compared to what I have delivered would be like too radically different projects and it has disappointed me that I did not get to deliver everything I had hoped for by the end of this project.

### **11.6 Student 2 Reflection: Jekaterina Pavlenko (K00224431)**

#### **11.6.1 Introduction**

This year I worked on my final team project, called PathFinder, with my course mates – Christopher Costelloe and Kevin Dunne. Christopher’s wife came up with an idea of the project and our group decided to bring this idea to life. PathFinder is an app that help people to orientate themselves in buildings, such as hospitals, airports, colleges, etc., and be cheap and cheerful to implement, and be useful in the real environment. The project involved web and Android mobile application software development – frontend and backend. Also, we were hoping to implement some hardware parts into our project, such as use of NFC tags and Bluetooth Beacons. The project seemed to likely and easy to implement, but as, usually, happens in the real life, we met some obstructions and issues during the project development. I think, my team mates did their best at the project contribution, including the project management and development. I’m not sure about myself, but I never happy enough with my skills and contributions. I will describe my personal opinion, how this project worked out for me, in details, further.

## **11.6.2 Contribution**

### **11.6.2.1 The Project management**

We were switching the roles every month, I think. We had Scribe, Chairperson and Attendee roles for the project management, so everyone had chance to experience the different roles. Scribe person supposed to do weekly meetings and upload it at GitHub, so it would help track what we have to do and achieve during the week and also check, did we succeed with previous 'list of things to do' in our project plan. Chairperson had to make sure what should be done and ensure that it is done. Attendee was taking important part in the meeting too, because he was taking part in the discussions/ideas/improvements to do.

First month, I was a Scribe person and took notes of the group meetings. With Christopher, we finalize the template of document for meetings to help orientate in the documentation later, if needed.

Next role, that I took, was a Team Leader. Well, I wouldn't say that I was pretty useful in this role, because, I think, such role should take a person with a more experience/background or with knowledge, what should actually be done. Also, the personality is also very important for this role. As I mentioned, in a previous individual assignment, I won't take this position willingly, I think, I'm don't have everything listed above, except maybe the fit personality. I will a Leader Role only if, the rest of the team members are, kind of, passive.

The last one was a Chairman role, which wasn't good one for me either, because, all the group were under pressure with assignments from other modules, including me. So we postponed most of the work, that should be done, during my Chairman position. I won't be pushing and putting people under more pressure, if I know they are having enough tasks to do at the moment, not forgetting to mention, that I'm the slowest member of the team as well, due to the part-time work as the kitchen assistant in the Horse & Jockey Hotel, some personal issues and a bad habit to do everything in the last moment.

### **11.6.2.2 Technical part**

- 1) Most of my contribution at technical part was designing the Web and Android Mobile Application Frontend, that anyway looked completely different in the end, and

developing it. I tried to implement an 'easy to navigate and use' approach for both of the apps. I used traditional HTML and CSS for marking up and styling it. I created a layout for both of apps to match, and to look sweet and nice.

- 2) Styling logos and banners for apps.
- 3) Registration and login for Web application evolving use of Java servlets and Database, which helped me to refresh some memories, how to implement it, from a previous year.
- 4) QR & Barcode implementation for Android Application. Made a research and watched some tutorials, how to do this. Basically, you have to import special libraries for QR/Barcodes, include a permission for turning on the Camera at Manifest document and some Java code for QR codes 'translation' or other words - to extract the actual data from the QR/Barcode.
- 5) Dropdown 'select' options for points at the Add New Points java servlet.
- 6) Opportunity to update the organisation or user information at Website as one of the controls of the Web App.
- 7) Cleaning up the code – HTML, CSS & Java.
- 8) The functionality checking and verification of Web and Android App.

So, mostly it was Web and Android beautification and some work with Java Servlets.

#### **11.6.2.3 Documentation**

- 1) Initial documentation was done by collaboration with Christopher
- 2) Literature Review – I did a research for NFC and Bluetooth Technology, unfortunately, we didn't implement them, eventually, in our project, due to supplies late order and delivery, and the amount of the work for other modules, etc.
- 3) Technical Report – all sketches/wireframes/architecture system/prototypes and so on example images was provided by me. Also, we broke the document into small parts, which was assign to a specific member of the team to split a work efficiently.
- 4) Presentation slides
- 5) Final Project – also was broken into parts eventually, when I realised that I need a help to cover some topics and speed up due to deadlines. A lot information had to be rewritten and reassigned to another specific topics. Also formatting part was very important as well, so I kept it structured and clean as possible.

Another thing, alongside Frontend, was done at documentation research, writing and formatting. I'd like to do a bit more coding part of the project, but Kevin was 'fast and furious' and keep doing everything really fast, so tried to help out with at least some backup things, such as design and documentation to be somehow useful for a team.

### **11.6.3 Issues**

#### **11.6.3.1 College**

This semester started about month later than usual, because of the course starting delay and when it eventually started, we got cut off 2 hours weekly for 2 important modules that could help us in the development of our project – Enterprise API development, which involves design patterns, using different web app IDEs and extra Java coding practice, and Android Mobile Application Development, which would have chance to give a better practice to develop an efficient Mobile app. I think, it was a big loss, because it is not only just useful modules, in the case of the project perspective, they are also very 'must-have' technologies & tools that companies would like people to have an experience in.

#### **11.6.3.2 Personal**

Working part-time and attending the colleges at the same time was very challenging for me. I did manage to do it well for first 2 years, but on the third year of the college I just started to burn out. I completely lost energy and motivation. I quitted the job at the beginning of this January, but it was too late, in my opinion, to catch up for some modules and projects. I did, what I could and worked with what I had at moment - some skills, that I could work with on the project.

### **11.6.4 Learning**

#### **11.6.4.1 Project management**

I learned about Agile methodology with Sprints approach and how it might help in planning in the project development. Also, we used a Gantt chart for planning the deadlines and assigning the task, that should be done, to a team member. I wouldn't say that we could ideally follow and meet deadlines related to the Gantt chart, but, again, we never included and considered the extra amount of the work that might occur during the final project development at this semester. Still, I think, it was a good experience to test this

methodology and partly apply for our project development. Most efficient thing for the project development were weekly meetings with the group members and supervisors. It gave the best push to the meeting and dealing with deadlines.

#### **11.6.4.2 Technical Skills**

I learned:

- 1) Developing a basic Android Mobile Development with Android Studio – building a basic layout, menu, activities.
- 2) QR/Barcodes implementation for Android Mobile App
- 3) Applying jsp for registration part of the Web Application
- 4) Using GitHub. It was completely new thing to me.
- 5) Using Eclipse IDE for Web Application development. After Netbeans IDE, Eclipse was quite annoying and took some time to use to it.

Also, I remembered, how to use Java servlets, phpMyAdmin.

#### **11.6.4.3 Interpersonal Skills**

I had a nice and supporting experience working with Christopher and Kevin. We didn't have any real issues, because we already worked with each other before, we knew that we are getting along very well, so decide to work on the final project together was, kind of, expected. So weekly meetings and meeting of the deadlines were attended and backed up, in the case of somebody's unforeseeable circumstances, by all team members.

#### **11.6.5 Strengths & weaknesses**

My strengths, I think, Frontend and Database design related to tech skills, as interpersonal strengths are teamwork and empathy.

Weaknesses are lack of confidence - I don't believe in myself and time management – the worst habit, I keep doing everything in the last minute.

#### **11.6.6 Conclusion**

It was a good experience and an amazing team, which I had a chance to work with. This project gave me a picture, how the Software Development Life Cycle looks like in real

environment. As a group, we had opportunity to apply most of our knowledges gained the last few years at the college, to learn from each other, to share the ideas and useful tips for the project development. Unfortunately, we didn't implement our project fully on 100%, but I'm happy with results and really appreciated for all help and support provided by team members.

## **11.7 Student 3 Reflection: Christopher J. Costelloe (K00233369)**

### **11.7.1 Introduction**

### **11.7.2 Project Background**

The project selected for us to complete as our 3rd year project was suggested by my Wife and then supported by the team members. We have all experienced issues (two from the team had the same issue in the same location), whereby it can be hard to find where you are going in a building, when the directions are not clear, or are not clearly shown. Sometimes the instructions are just so long that you cannot remember them all and end up getting lost.

Hence, we came up with the project: PathFinder. This was a cheap and cheerful method for anybody or organisation to implement, that would allow a user a free way of navigating buildings / areas with the minimal of cost (data charges) while the cost to the organisation would be minimal.

The idea was quite simple, we have a user scan a barcode or QR code (Bluetooth and NFC are part of the solution but was dependant on getting the hardware approved and shipped on time), and this would then give us the users starting point on a map. Next, the user would select where they wanted to go, and we would then generate a set of text instructions to inform the user on how to get there.

The user could check their progress while in route by scanning other QR/Barcodes to see if they were still on the correct path or not.

### **11.7.3 Course Specific Issues**

Considering what the team had accomplished in both Year 1 and Year 2 of College, this project seemed to be relatively easy but we had not taken into consideration all of the



other work, delays, exasperations and general overloading of work, that would we have to deal with, along with all of our own personal issues and problems, and still deliver a working, documented solution.

We had a lot to learn, a short amount of time to learn it, a shorter amount of time to try and implement it, and what time was left, was insufficient to allow for the team project to be a success that we all had planned for it.

Some of the issues that affected us (and this list is not exhaustive);

- Late start to the college course as the college was initially not going to run the course and therefore, we lost about 7 weeks of initial education.
- When the course was run, it was decided that the unique modules to this course would be reduced from 5 hours per week, to only 3 hours per week, once again affecting our ability to learn new systems, functions, methods.
- When we first submitted our project and it was approved, we were then affected by trying to obtain the necessary hardware to allow the project to move forward, as planned.
- Making use of software in a room that is nearly 100% occupied by first and second years, made it nearly impossible to complete one of our assigned tasks – the generation of Gantt charts which needed authorised software that was installed on machines that we have extremely limited access to, on a date approaching the due date of the submission for that part of our project.
- Reduced semester time to allow for longer work-experience time.

#### **11.7.4 Self-reflection of learning**

##### **11.7.4.1 External course learning**

A lot of what we had to learn could be done in college, through the normal course of the semester but our project did involve technologies that we had never used before, that would not be covered by any part of our course. Some of these technologies are;

- Azure Database hosting

- Azure Web Site hosting
- How to send and receive a picture in Base 64 encoding (from web-site to database and back again)
- How to get a server to send back a JSON response to a request for either logging in or for data
- QR / Barcode reader for Android
- Bluetooth / NFC reader for Android (not implemented in the end due to delays in getting the hardware).
- JSON response to Android request for data

When you consider all that we had to do on our own, (mainly Kevin as he was the main developer on our project, with great backup from Kate), to have what has been developed, and to be able to show that this basic app actually works, and can do basic route finding, means that we have accomplished quite a lot in a shorter period of time, than expected.

#### **11.7.4.2 Technical**

From a technical point of view, the Team has had a lot to cope with as some of the coding that needed to be done, could not be completed on a PC as there was a dependency on physical hardware needed to test the coding done.

From my perspective, I was more of the ideas man and how to get what we needed done. I became a resource facilitator, informing my teammates of software and utilities that exist to test out certain items on our project.

**Storing images on a server** is not that big of an issue, but storing the images in a database, as a piece of data in a row, was something different. This can be done by using Base 64 encoding and decoding. I learnt this from working on another project that allowed the user to take a picture, that then had to be uploaded to the server in a base 64 encoded string. The server could then show that same picture to the user on a web page

**Network communications** are an integral part of any development where the data is stored on a backend server. At some point in time, the application will need to contact the backend, to find out something and the backend will respond in a specific manner. This is where an application / utility called “postman” can be of great use. This application allows you to send in a HTTP REST request and receive back a response from the server.

Having a tool like this allows the developer to test the web API without having to write a fully functional web page or application.

**JSON (JavaScript Object Notation)** is a way of representing data as a Key/Value pair. It is considered a Dictionary and allows for arrays and data structures such that there is an encapsulating element that contains all the information. You can then find the information needed within this data structure by either parsing the whole structure bit by bit, or you can use the key/value pair to find a piece of information.

**Integration of this technology** was new to the other team members, but I had used most of this in another project, on another platform, for another purpose. Putting all of this together on the web backend and on Android, was new for all of us but it seemed better to allow a single individual to work on the whole area as it is all interconnected to a great extent and if you know how the database is designed, where it is located, how to access it, then working on the web site to connect to the back end and the same for the Android App, appeared to be geared towards a single user for development. This was a mistake on my part, when I was leading the project.

**Technical task assignment** was based on the new technology we were using, where we all had a lot of learning to do. Unfortunately, this all ended up in the lap of Kevin Dunne as Kevin became responsible for setting up Azure, the database, the web site and for getting it all up and running. This was then extended to the Android Application as well.

For Kate, we had the design element of the Web site and the Android Application, some documentation and the implementation of the QR/Barcode reader for our App.

My end was supposed to be the blue tooth communications and the NFC tags. It ended up that these were never implemented due to the late arrival of the hardware. The only other piece of technical work left, was the algorithm for the working out of the path from the

source location to the destination location. This did not work well for me and I had to resort to asking Kevin to step in and help me out.

Though I have a working example of the code and it does find the shortest path from A to B, I needed help in integrating this solution into our application and since Kevin is the brains behind the database, it was his help that was needed the most.

### **11.7.5 Project Management**

#### **11.7.5.1 Project Manager**

For my stint as Project Manager, at the start of the project, I was responsible for setting up the milestones, the deliverables and the timeline for our development. This is all relatively straight forward but does require you to try and break down every single aspect of the project into its smallest possible aspect, so that these can then all contribute to the overall completion of the project.

The Team worked well on this and we used Excel extensively for the setting of the splits that we would need on our Gantt chart. Thanks to Kevin and his ability to work late, the Gantt chart was completed on time and delivered as needed.

Both Kevin and Kate have had the role as Project Manager as part of our team workings, each member must hold each role available for a part of our project. Both have worked well in all roles assigned.

#### **11.7.5.2 Chairperson**

Each person on the team has been the Chair of our weekly meetings. The role of the chairperson is to make sure the meeting starts on time, that all attendees are present and that we follow the minutes of the previous meetings and then address any new or other business.

In this case we have all held the position and have all worked to make sure we have our weekly meetings (even if they are deferred by a day or so) and that each and every meeting is positive and shows us where we have been and where we are currently going.

Meetings allow for all members of the team, to catch up and understand what the other members are doing, and where we are in the course of the actual project, and what the upcoming deliverables are.

### **11.7.5.3 Scribe**

Though the role of the scribe is not a vocal one, it is important for the scribe to make sure that the meeting is correctly reported in the “minutes of the meeting” and to seek clarification if some point or issue is not clear. The minutes represent what was discussed, what was actioned and when actioned points should be completed by. If this information is not correct, then the project can suffer delays or work may not be done, due to incorrectly documented minutes.

Every member of the team has done some work on being a scribe and the layout of our “minutes of a meeting” comes from one of the previous jobs I worked at. It worked fine there and appears to have worked fine here as well.

### **11.7.6 Documentation**

We have all worked on the Project Proposal document, the Technical Proposal document and the Literature Review document. We all took on specific parts for each document and we all delivered what was needed, when it was needed. We all did reviews on all documentation done to ensure it was of the highest possible quality and to ensure that we all understood what was needed and what had/must be delivered. We have constantly reviewed each other’s work as well as our own, to ensure that we are all working from the same perspective.

### **11.7.7 Teamwork**

As we are all located quite a distance from each other, the Teamwork was organised via Facebook Messenger, Weekly Meetings and discussions between the classes we were attending. If needed, we would meet up either earlier or later in the day, to discuss items of any concern.

All members of the team were quite open about all personal issues that could directly affect that user’s ability to work on the project and complete assigned tasks. This prevented any one person from bringing down the team or adversely affecting the project and the deliverables.

### **11.7.8 Issues / Problems**

#### **11.7.8.1 Team**

As such, the team did not experience any real issues within itself, though personal issues did exist that did affect the team, these issues were not with the team.

The only issue that existed within the team was to do with the name of our project and how to spell it. We have three team members, one wanted to spell the project name as “PathFinder” (with a capital ‘F’), another wanted “Pathfinder” (with a small ‘f’) and the third (me) just sat on the fence and would not push for either one.

There was a specific reason for this. If there is one small issue that exists, if left unresolved and if it is not impacting the project, that small issue can be used as a means of releasing tension, getting the team to laugh about something small like that, can lead to other members opening up more about the issue that they have and how that issue could affect the team or the project.

Having a small issue left unresolved, allows for it to be used in a way to actually resolve and highlight that not all issues are as big as they seem and once discussed, can be handled in a way that will allow the project to move forward, on schedule.

##### **11.7.8.1.1 Resolution**

This issue of the project name was never intentionally resolved. It has been left as a means to all others to comment on and through its existence, to allow for the discussion of other more important issues. The actual spelling of the project name is not that important, till the final documentation, when the issue can then be finally resolved without impacting on the project in any way.

#### **11.7.8.2 College**

As discussed previously, late start to some of the modules, shorter hours on those modules and the delay in getting hardware approved, these did all have an impact on our project, but more in an emotional and frustration way, than an actual project deliverable way.

##### **11.7.8.2.1 Resolution**

Our project from the start was designed around “finding a path” in a building or area, using QR Codes, Barcodes, NFC tags and Bluetooth beacons. As the NFC tags and Bluetooth beacons were not available, this did not impact the development of the project using just QR Codes and Barcodes. We could, if needed, then add in the code for the NFC Tags and Bluetooth beacons at a later date.

#### **11.7.8.3 Personal**

We all have personal issues and sometimes these, through bad decisions, can cause issues that affect a lot of other people, and the work that we do. This semester was a list of these bad decisions for me. From, but not limited to

- Incorrect hardware purchased for the term (AMD instead of Intel chipset)
- Change of job – was supposed to be shorter hours but ended up being more hours
- Time management – due to supporting the family, available time for college work was not available.

#### **11.7.8.4 Resolution**

Work arounds put in place to get the hardware working. So, it can now run some of the applications but in a limited mode (such as Android Studio but cannot run the emulator, so need a physical device instead). Gave up the job to have more time to work on the project but the project deliverables had already been affected.

#### **11.7.9 Conclusion**

If we could have planned our personal time better (especially for me) and had the funds so that having a job would not have been an issue, then the project would have fared better.

We could have organised more time for the team to work together, to enable a better and more comprehensive solution to be delivered, as we would all have been working on all aspects of the project, at the same time.

The main problem that we faced as a Team, in my personal opinion, is that for a group of people working together for the first time, it is necessary to work a lot of the time in the same region / area as the other team members. This allows for all members to take part in

all aspects of the project development. Seasoned teams, can work remotely and have great success as they know each other, know what each member can do, know what will and will not be delivered, but for a fresh team, all this has to be learnt, and that takes time but the initial working together, is where the team bond is formed and where team members find out what and how we all work together.

The project has been a success, in my opinion, as we have not only delivered a working sample of what we intended to deliver, but we have also delivered on the projects for the other modules. In essence, working on four smaller projects, while also working on a substantial project at the same time.