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| **Implementing improved methods of Patient care using IoT, Mobile Devices and Website Applications**  Aaron Stones  BSc Computing with Honours, 2020 |

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| School of Design and Informatics  Abertay University |

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# Table of Tables

# Acknowledgements

# Abstract

300 words

Usually read first by the reader

Write this last

Summarise what you did, results and conclusions

Not an intro so no references

# Abbreviations, Symbols and Notation

If required

# Chapter 1 – Introduction

**750 – 800 words + 133 words per section**

**Set the scene**

**Background to and purpose of the investigation**

**Scope**

**Project aims/research questions**

**Likely to be more focussed than the proposal**

**End with an overview of the remaining chapters**

### Aims & Objectives

|  |  |
| --- | --- |
| **Aim** | **Objectives** |
| Analyse the methods of which detection of incurable neurological disorders are carried out to utilise IoT and Mobile Devices, so a system can be developed that can be analyse and decide the best courses of action. | * Identify through interviews and research with medical professionals and literature what tests are used within the medical world to diagnose these issues. * Identify the methods used by medical professionals to monitor the progress of the disorder and provide effective care, to see if these can be or already have been digitised, and if so, can they be made more effective. * Analyse the data that has been collected, to develop a system to show graphs patients state either; bettering, deteriorating or stabilising. |
| Design an effective management system that incorporates all three technologies (Web App, Android Application and IoT device). | * Identify the system logic through the creation of a System Diagram. * Depict how the user data will be stored within the server through the creation of a Database Schematic * Create a diagram to show how each technology will be interconnected throughout the system. |
| Develop a system to manage the patients effectively with the three technologies. | * Review and select the best methods for measuring a patient’s vital signs on both IoT and Android Devices. * Replicate the systems in place where possible and create new Algorithms where none exist. * Analyse the best free to use Application Programming Interfaces to display a patient’s results in graphical format. |
| Analyse the effectiveness of the system as a whole and the communication between integral parts. | * Conduct System Testing to make sure the system as a whole works effectively. * Conduct Unit Testing between the server and three devices, this will depict whether communication is effective or not. |
| Create an effective test plan to ensure the system is operating as planned. Test plan must incorporate an ability to measure accessibility as this system is for Elderly patients. | * Follow Test-Driven development to ensure code is secure and best practices are followed. * Unit testing will be conducted on functions to ensure functions and components are working as expected. * Accessibility testing must be conducted to ensure the system can be used by all patients. |
| Test the effectiveness of the measurements taken on both IoT and Android Devices, also how the results are presented within the web app. | * Analyse the results based on the developer’s vital signs taken with reliable medical instruments. * Compare different graph API’s to select one with a line of best fit and that is free to use. |
| Evaluate the hypothesis of the project using Interviews and Surveys with medical professionals and the public. | * Assess the test subjects’ thoughts and opinions on the software using unstructured interviews. * Construct a following structured interview to gain data pertinent to evaluating solely the hypothesis. |

Within the United Kingdom right now it is estimated that around 410,000 people live inside ‘Care Homes’ (GOV.UK, 2019). Around 10% of these residents have primary health options, this means the patient is no longer able to look after themselves and have been admitted to residential care to protect them. A following 49% of the residents in ‘Care Homes’ are LA-funded, this is a scheme setup by the United Kingdom government to contribute to a quarter of the living costs for these residents (GOV.UK, 2019).

However, it has been reported within the media recently that due to an ever increasing and ageing population, a need for patients to be admitted due to concerns for their health (primary options) out-ways the need for these forms of care. This is in comparison to residents on LA-funded schemes, who could achieve an equally adequate or even better form of care from their own homes through the use of technology. This technology could be used to manage the different conditions patients may have or used to detect these conditions early.

Within these ‘Care Homes’ many patients are living with both; early and advanced neurological brain conditions and require regular assessment from Nurses and Doctors to assess the progression of their disease and any notable changes. This only happens if a patient has been correctly diagnosed. If Parkinson’s is taken as an example according to WebMD – “It has been estimated that, especially in its early stages, nearly 40% of people with Parkinson’s Disease may not be diagnosed, and as many as 25% are misdiagnosed.” (WebMD, 2019) This shows a lack of ability to accurately detect this conditions and so accurate care cannot be provided. The main means for the detection of degrading neurological conditions is the use of CT scans, which are both time consuming and expensive to public bodies like the NHS (National Health Service), with each scan costing around 609.70 pounds according to costevaluation.com (Costevaluation.com, 2019). This is a necessity to accurately detect neurological conditions but are in high demand. Mobile Phones and IoT devices could be used to run small tests before hand by the suspected sufferers to give an early prognosis of these conditions where then the CT scan is only a formality to confirm what is already known.

# Chapter 2 – Literature Review

## 2.1 Introduction

This chapter investigates the work that has been proposed already to help ensure effective care is given to patients, and new forms of technology that could be used to help manage the effective care given to patients. There have been many studies into the way in which readings have are taken from patients and how these readings are; stored, processed, analysed and displayed to medical professionals. Many of the methods that are used to collect data from patients have not been updated for decades. For example, if the study ‘How reliable are clinical systems in the UK NHS? A study of seven NHS organisations’ is considered, the conclusions drawn from this study stated that “Reported reliability was low for the four systems studied, with some common factors behind each. However, this hides significant variation between organisations for some processes, suggesting that some organisations have managed to create more reliable systems. Standardisation of processes would be expected to have significant benefit.” This highlights that a lack of consistency between organisations is present and the need for consistency to be able to effectively manage, care, medicines and management of services (Burnett S, Franklin BD, Moorthy K, et al, 2012).

In measuring a person’s health much of the process involves a lot of medical supervision. Most of these are simple readings such as Heart Rate, Temperature, Weight, Blood Pressure. Most of the readings can be taken through new technologies such as smart phones and internet of things devices. Especially smart phones, which contain many sensors built into them can take a plentiful supply of readings from a patient without the need of a medical professional to be present, in the taking of these readings. These tests could be extended and upgraded to provide extra care for patients suffering with degenerative mental health conditions, using the previously mentioned sensors within IoT devices and smart phones. To conclude, the three main areas that are being targeted are the NHS and data collection within the NHS and the basics about IoT devices and smart phones.

## 2.2 NHS and Data Collection

To monitor a patient’s health, basic readings are taken like, Heart Rate, Temperature, Weight, Blood Pressure. To take these readings, a patient is either required to visit their local hospital for an appointment with a Nurse/Doctor, or if they are incapable due to disability or old age, a District Nurse would be sent out to retrieve the readings. Possibly, a patient could wait for hours for these simple readings to be taken and for advice to be given to the patient. To take this further, a patient suffering with Parkinson’s has little ways to help manage the disease, both medically and within their lifestyle. After a patient has been diagnosed with the disease they are taken for monthly assessments with a Doctor or specialised Nurse, where their tremors are visually looked at and the patient is asked if they have any concerns. At this point the appointment is complete and the patient is sent home with an action plan and appointment for the next month. According to the Patient website, a person with the Parkinson’s disease should receive; Parkinson's disease nurse specialists, Physiotherapy and physical activity, Occupational therapy, Speech and language therapy and Nutritional support (Tidy, 2020). Within the United Kingdom due to shortages within the NHS, the amount of recommended care for a single patient cannot be provided to every sufferer of Parkinson’s. This means that only a Doctor’s appointment or a specialised Nurse can see a patient each month, they report whether further action is needed or if the patient is fine. If a patient requires an extra appointment for any reason, they are required to visit their local General Practitioner.

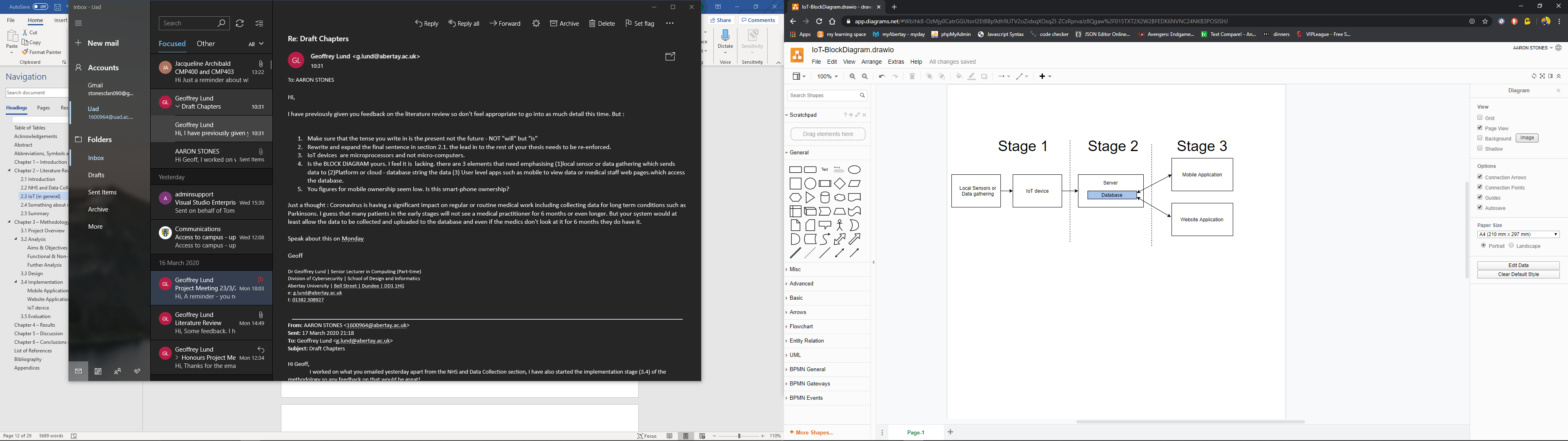
The care needed for patients with Parkinson’s cannot be provided within the United Kingdom, as previously stated, which means there is a need for change in which the way the disease is managed, and other diseases are managed. This would allow for resources to be freed up to allow patients to get the care that they need and deserve. Also, what is needed is for data that we are collecting from patients to be increased to give a better understanding of how a patient’s condition is either degrading or improving. This would also prevent unnecessary hospitalisations because a more comprehensive view of a patient’s health has been gathered and a better understanding of their health has been gained. Within the clinical investigation ‘Residents: Frequency, Causes, and Costs’ it is suggested that the unnecessary hospitalisation of patients is likely to cause their health more issues due to the stress of being transferred to a hospital. The study then goes onto state that 67% of hospitalisations are avoidable and take up a great deal of NHS resources. These resources could be better utilised if it is found out that a patient did not need hospitalised. This also works if the patient takes a reading that a medical professional does not like, and a life is saved because they were hospitalised with a serious condition.

With the NHS being reported as “A&E waiting times in England at their worst on record” (Guardian, 2019) just as little as five months ago and various other stories reported in the media daily as to an NHS that is under pressure. Solutions need to be put in place for situations like bed blocking, which is reported in the Guardian as “Hospital ‘bed blocking’ numbers hit highest level since 2017” (Guardian, 2020). So there is a real problem with patients attending hospitals when there is no real need for them to be there, blocking other patients from getting the urgent medical care that they need. With an ever-shortening budget to the NHS as well, there is no hope of being able to fund the issues the NHS is currently facing and new means of effective patient care need to be introduced.

## 2.3 Micro-Processors

Devices that have been previously mentioned can take lots of readings and send them to a server. One of these are IoT devices, or internet of things devices, these are microprocessors that transfer data over a network to a cloud server without the need for Human-Computer or Computer-Human interaction. They carry a relatively low amount of processing power, RAM etc and are mainly used for the sending of data. The fact they have low system performance means that they are very inexpensive pieces of technology and are simple to setup and utilise. Within the United Kingdom they have been used for devices like the Nest Thermostat – a device that is programmable and self-learning device that optimises the heating and cooling of homes, Berennis Smart Light Bulb – allows a user to change the colour and brightness of the light through an application on their phone, Sense Energy Monitor – a device that is installed into a home’s electrical panel to provide insight into energy usage within that home through the use of mobile and we applications etc (Mishra, 2020). These devices can send and receive data from a server, the server usually acts on data based upon a user entering an input or a sudden change in the data being received by the server. These devices (as can be seen from the previous examples) can be programmed and have sensors added to them to provide different functionality for the user and send different kinds of data to a server. If this technology is applied in a medical sense, the NHS has put IoT devices through a rigorous testing phase. “As part of an initiative to set up testbeds to pilot new technologies in the health service, NHS England and the Department of Health has awarded £10m in funding to two 'test bed' projects that it describes as "IoT-led".” (Best, 2020). One of these projects is called, TIHM or Technology Integrated Health Management. This system is used to monitor patients with Dementia, reduce the need for hospital admissions and relieve the stress on carers (Sabp.nhs.uk. (2020)). The devices used are IoT devices, they send a signal to clinicians when they detect an issue with the patient such as falls, turning on things they shouldn’t and long-term periods of idleness.

The functionality of an IoT device is simplistic, local sensors or data gathering instruments pass data onto, or are built directly onto the IoT device. From this these readings are either sent to a platform or a different cloud platform, from which, the data could either be stored within a database, like what is shown in the diagram below, or processed directly on the cloud platform. This could then move onto a third stage of informing a user about a change in the data stored within the database or directly send notifications from the cloud platform to a user’s mobile application, directly to their smart phone, or the data that is being presented within a website application.



## 2.4 Mobile Applications

A further device that can be used in this context and has a quantity of highly sensitive sensors, are Smart Phones. These have the advantage over IoT devices, that they are widely used and most of the U.K has a mobile phone, the age group with the lowest percentage of mobile phones is 55 and over. This age bracket has a percentage ownership of 55%. All other age groups above the age of 16 have an ownership greater than 90% (O'Dea, 2019). Most Smart Phones within the U.K have the ability to communicate with a web server from almost everywhere with the use of Mobile Data and Wi-Fi in U.K homes, this allows for convenience when a User is required to send or receive data from a server. Receiving data anywhere, allows a User to keep up to date with any changes within the server, due to new data being entered or data needing to be entered. Examples of this have been used within rural countries within Africa, the technology is called tele diagnosis and it is used for patients to communicate with Doctors by sending them photos, information etc about their ailments and a Doctor can send different courses of action or treatments. The technology has been widely successful due to the instantaneous nature of Mobile Phones and the quality of the cameras, microphones etc to help a medical professional make an informed decision on the best course of action this is usually done through the iSAT solution, to use highly qualified urban doctors to provide medical aid from a distance (User, 2020). As previously mentioned, the quality of the sensors within mobile phones are incredibly sensitive and can detect the smallest changes in movement, heat etc. sensors have been increasing in quality since 2014. GPS or Global Positioning System also allows people to pinpoint their locations and track their movements, whether that be for fitness, or for their own personal safety. GPS has been used to track elderly people with degenerative brain conditions such as Dementia to plot a circle as to an area where they are meant to be. If a Dementia sufferer travels outside of the circle set out by a program, a signal is sent to a server and a next of kin, carer or medical professional are contacted to check on the safety of the patient called geofencing. This means if a Dementia sufferer gets confused and lost, the carer can locate them and bring them back home. Mobile Applications can communicate with a server this allows for communications between a web app and a smart phone also. This allows Users to, manage data entered onto a Mobile Application and User data or content within the application etc. They also provide a failsafe if a User forgets any of their login data.

## 2.5 Summary

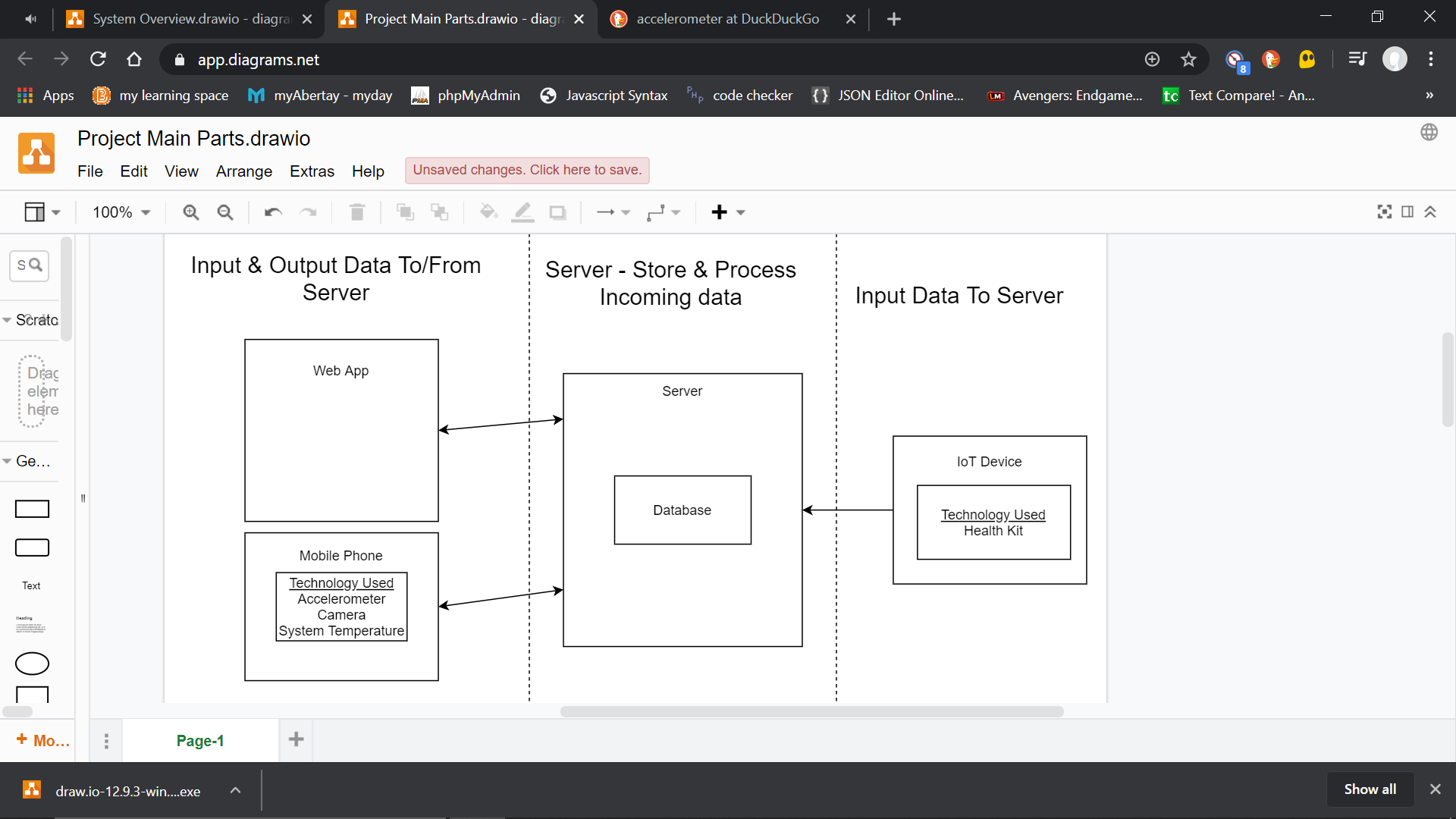
The purpose of this Literature Review was to analyse trends and common practices of technologies used within the NHS and other technologies used out with the NHS, as well as current methods the NHS utilise to manage data collection. With what has been discovered through the research conducted, IoT, smart phones, website applications and a server could be used to implement an effective technology for the management of elderly patient’s health. This management system could cut down on the time spent by medical professionals within the NHS from taking simple readings from patients. This could also improve the management of patients using Databases to store results from patients and report back to medical professionals (in graphical format), if a patient looks to be improving or degrading in their health or their condition.

# Chapter 3 – Methodology

Within this Methodology chapter, an explanation of the processes involved in the development of this project is be given. As well as, the justification for these processes. Techniques such as System Diagrams, Test-Driven Development, MVC, Surveys and qualitative Interviews are discussed to show exactly how this project was created. The project followed a Waterfall development process, following the classic, Analysis, Design, Implementation, Testing and Evaluation steps. However, the way in which changes and suggestions were implemented have been handled in an Agile format. This allowed the developer to cope with these changes easier and track the progress of the project with greater ease.

## 3.1 Project Overview

In Lehman’s terms, this project looks to build a system that tracks different health measures of a patient. These measurements include, heart rate, blood pressure, body mass and patient temperature. These measures are coupled with a hand shaking test developed as well. The hand shaking test, is utilised within the Mobile Application and is used to measure the rate at which a user’s hand is shaking and plot a graph as to the degrading or improving condition of a patient based on the number of shakes that are greater than a set threshold. The data is taken when a user is filling out the forms on the ‘Take Test’ page within the Mobile Application. These measures are sent to a server where they are stored and presented to medical professionals in graphical format, this allows the medical professionals to gain a better idea of patient degradation or improvement. The readings are taken by sensors on a mobile phone, such as the accelerometer for measuring the intensity of handshakes, for patients with Parkinson’s. These readings are all taken on a mobile phone. Not everyone in the United Kingdom has a mobile phone, so an IoT device is setup and uses a health kit to take simple measurements (this device cannot conduct the Parkinson’s measurements). The medical professionals take all the data that has been posted to the server and allow medical professionals to select patients and see their results, while communicating advice to patients and send messages/advice to individual patients.



As is shown in the diagram above the server is pinnacle to the success of this project, because of this an effective Software Design pattern was followed. The design pattern selected was MVC (Model View Controller). This has been selected for the clear ability to separate the View, or what the user sees, from the processes being conducted on the server. This means that when the mobile phone, IoT device or Web App contacts the server, these technologies are utilising the same APIs within the controller and is therefore reducing the amount of code repetition within the server. If there is any need for code redevelopment, changes to the devices or updates these can be conducted easily within the server due to the use of the software design pattern MVC

## 3.2 Analysis

As Initially stated, the first stage undertaken was an analysis of the subject. This involved; a meeting with the subject specialist to see if the project idea was feasible, the creation of Aims & Objectives, the production of Software Requirements and an analysis of the requirements of each piece of software.

These Aims & Objectives have been set out to provide a clear direction of the project. They have also provided the basis for the development of the Functional and Non-Functional Requirements and will form the basis of testing to ensure either the aims and objectives have been met or have not.

### Functional & Non-Functional Requirements

|  |  |
| --- | --- |
| Functional Requirements | |
| FREQ ID | Requirement |
| FREQ001 | Users must be able to register an account |
| FREQ002 | Users must be able to login to an existing account |
| FREQ003 | Users must be able to easily contact their Doctor |
| FREQ004 | Users must be able to perform a test on a mobile and an IoT device |
| FREQ005 | The user must have an option to enter in readings manually that cannot be taken by a phone or IoT device |
| FREQ006 | Users must have a way of displaying readings in graphical format for review |
| FREQ007 | Users must be able to receive advice from all medical professionals based on their conditions |
| Non-Functional Requirements | |
| NFREQ ID | Requirement |
| NFREQ001 | This application will be responsive, and users will therefore be able to operate it with ease on multiple types of devices including mobiles, tablets and computers. |
| NFREQ002 | This application will be reliable, this will allow users to operate it with a high degree of trust, knowing that it will work as they expect it to. |
| NFREQ003 | This application will be scalable as it will accommodate heavier loads and large number of users. |
| NFREQ004 | This application will be maintainable by the developers, and any other teams that work on it due to its thorough documentation. |
| NFREQ005 | This application will use secure practices, as it will be fully compliant with the Data Protection Act, meaning we will store the data securely and for the correct amount of time. The team will comply with the General Data Protection Regulation. |

As well as Functional & Non-Functional Requirements, many rules, regulations and standards must be followed throughout the development process. Some of these, have been set out by the I.E.E.E (Institute of Electrical and Electronics Engineers) or I.S.O (International Organisation for Standardisation). There are plenty of regulations set out by these organisations that the developer has followed these throughout the development phase. (www.tutorialspoint.com, 2018)

There are two main Laws that the developer respected and followed the first one is the Computer Misuse Act. The developer has set out strict rules as to what they should be able to be done with the produced software and is well informed of the risks of ‘hacking’ and leaving security issues within the code. These steps have been taken to ensure the team does not breach these laws.

Just as the utmost care must be taken for the Computer Misuse Act. The same due attention must be taken for the Data Protection Act. This Law must be respected, and user data must not be delegated to any unauthorised personnel. The developer has also developed the project with the utmost security to ensure that users will not have their data unlawfully distributed.

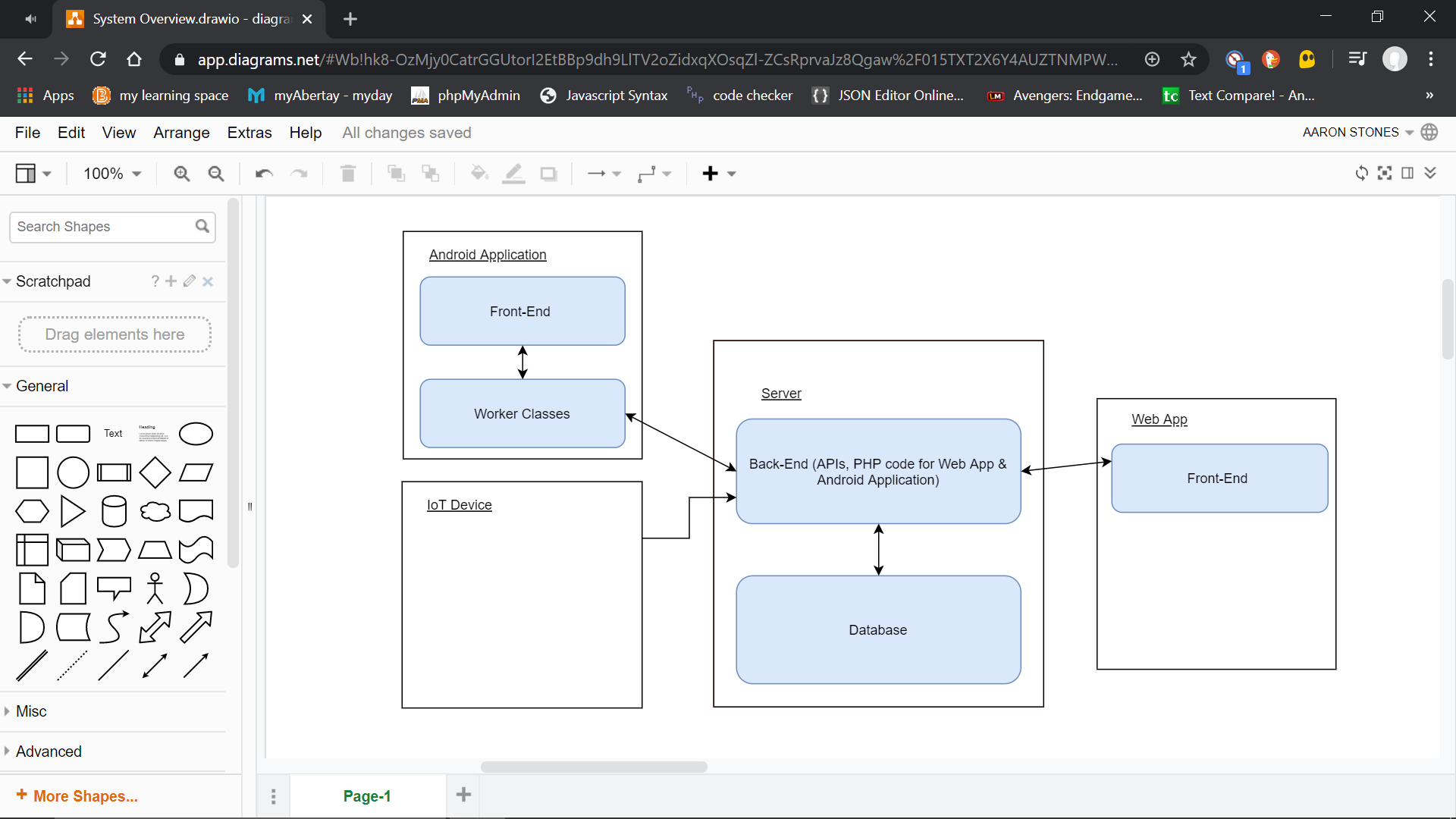
### Feasibility

Within the initial meeting between the developer and the subject specialist, the idea was put forward and discussed as to whether it was feasible or not. The subject specialist agreed the project was feasible and thought and added insight into what would require the most work and what would require the least. This was highly beneficial to the developer as this gave valuable insight into the time scales for the developers Gantt Chart.

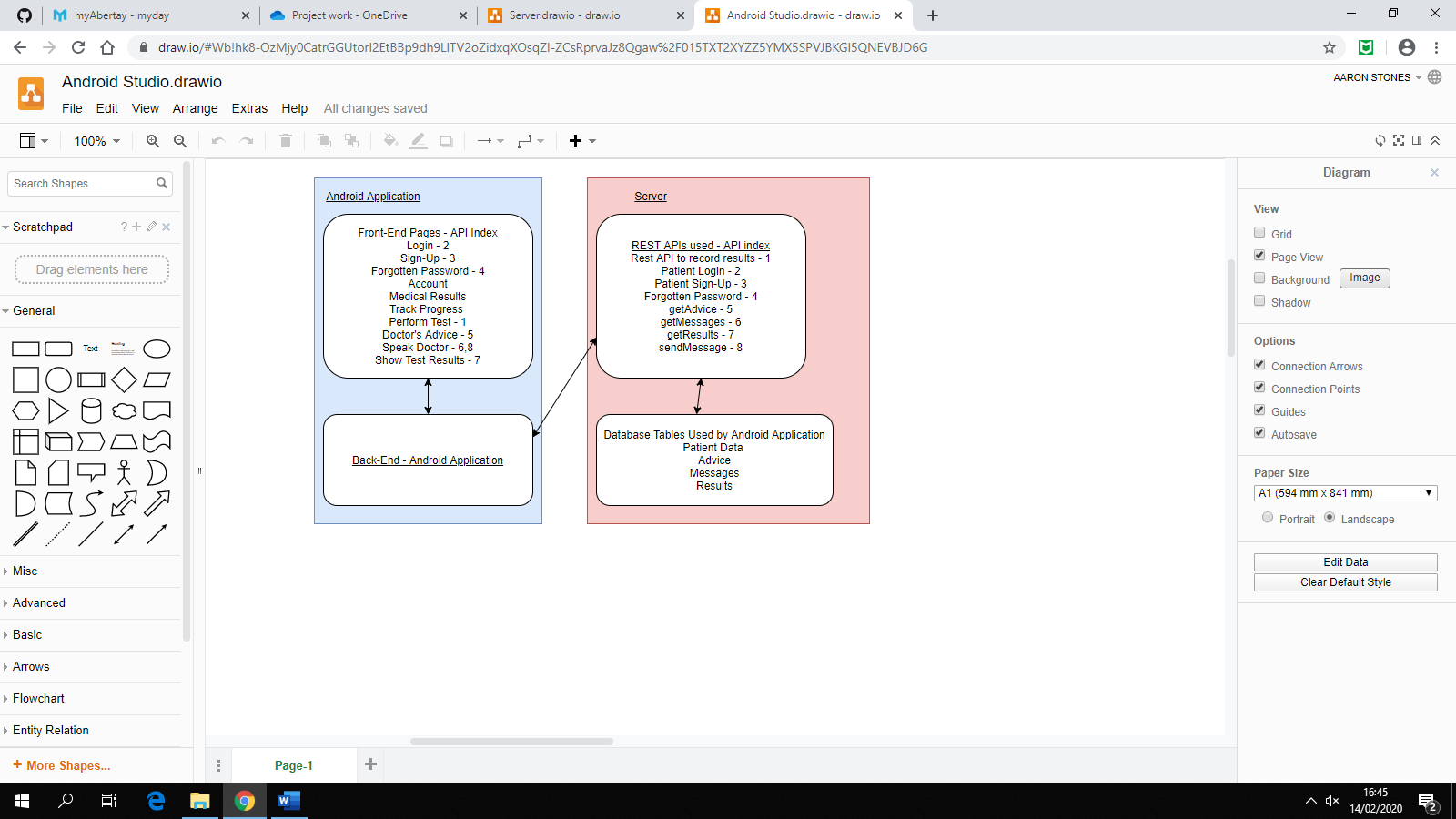
A review of the facilities at Abertay University had to be conducted to decide whether outside software needed to be utilised. This was not the case and Abertay University had all the necessary features required to develop the project. These were decided as A Website Application for the Medical Professionals to be able to monitor the patients. This uses technologies such as the LAMP (Linux Apache MySQL and PHP) stack, coupled with HTML (Hypertext Mark-up Language), JavaScript and CSS (Cascading Style Sheets). Following this, Android Studio was selected to develop the Mobile Application; firstly as Android devices are some of the most commonly used devices in the world, to develop on iOS for Apple devices a Virtual Machine would need to be used to run MacOS and this would be awkward and cause issues during testing because the developer only has access to an Android running phone, so could not accurately prove this concept.

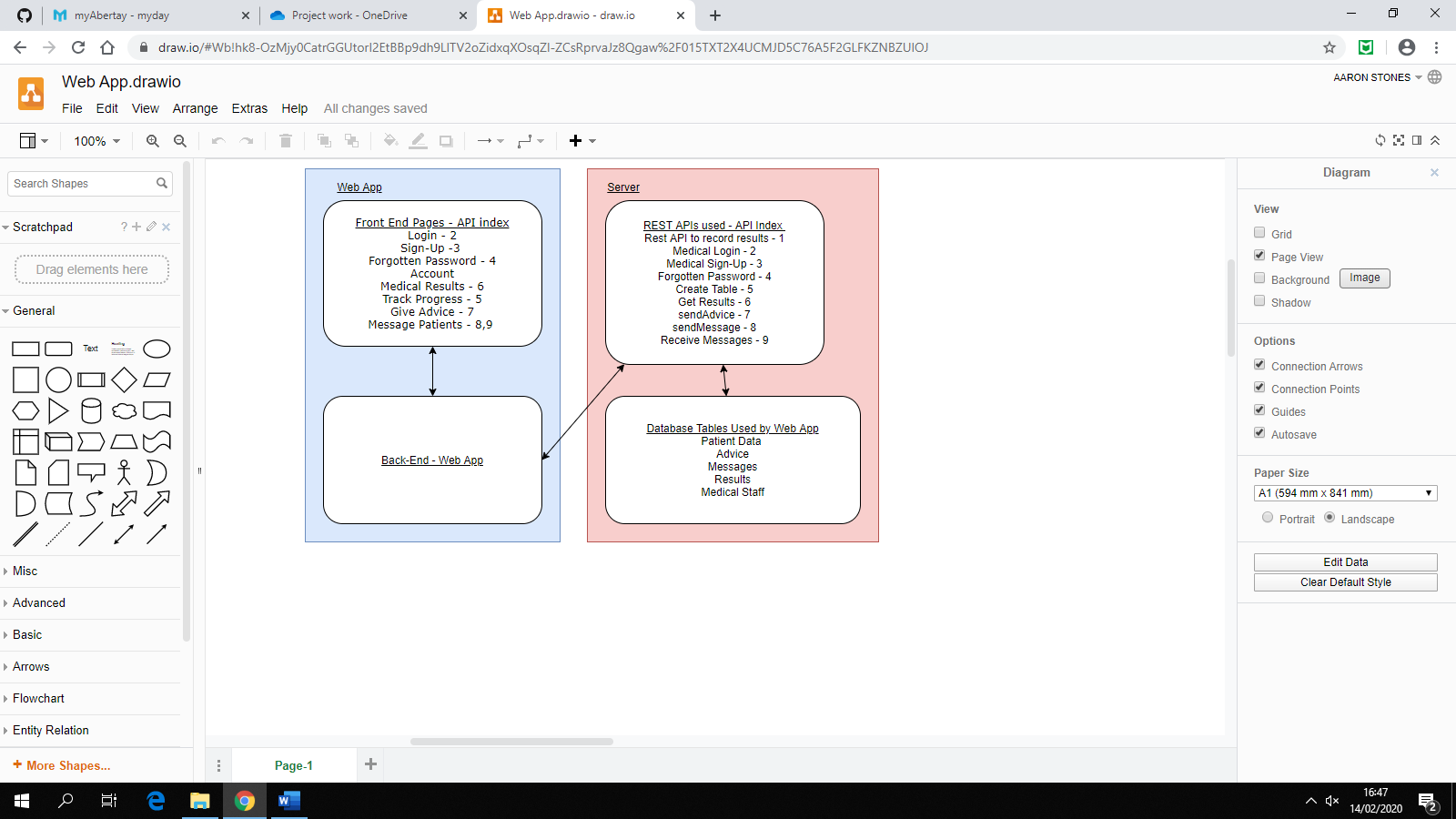
## 3.3 Design

As previously stated, these devices must work in tandem to show the results from each on the medical professional’s website application. So, to initially understand the logic of the system, a System Diagram was created to show the communications to and from the server and between devices. As shown below.

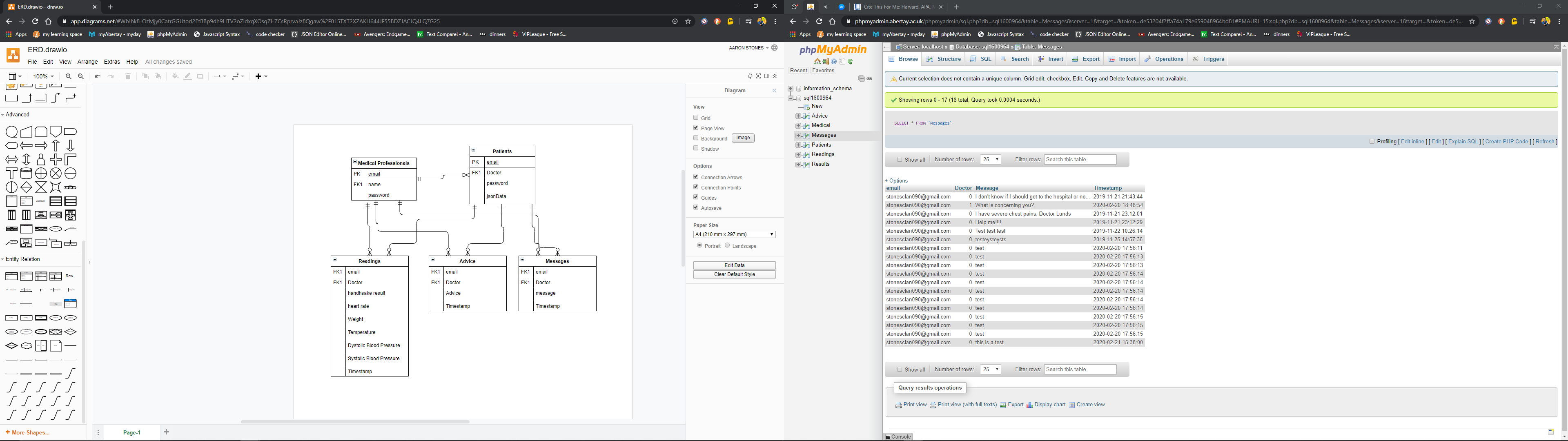


As shown above, all devices send and receive data to and from a centralised server. This allows all data to be kept within the same place and allows ease of access between devices and the data, using APIs (Application Programming Interfaces) within the server. This server supports the backend programming language called PHP. Therefore, all APIs are coded within PHP. The APIs are contacted by multiple devices, for example, to record results as both the IoT device and Android device are recording most of the same results. This means that the same APIs can be used by multiple devices. A diagram has been created to show the communication between devices and the APIs.

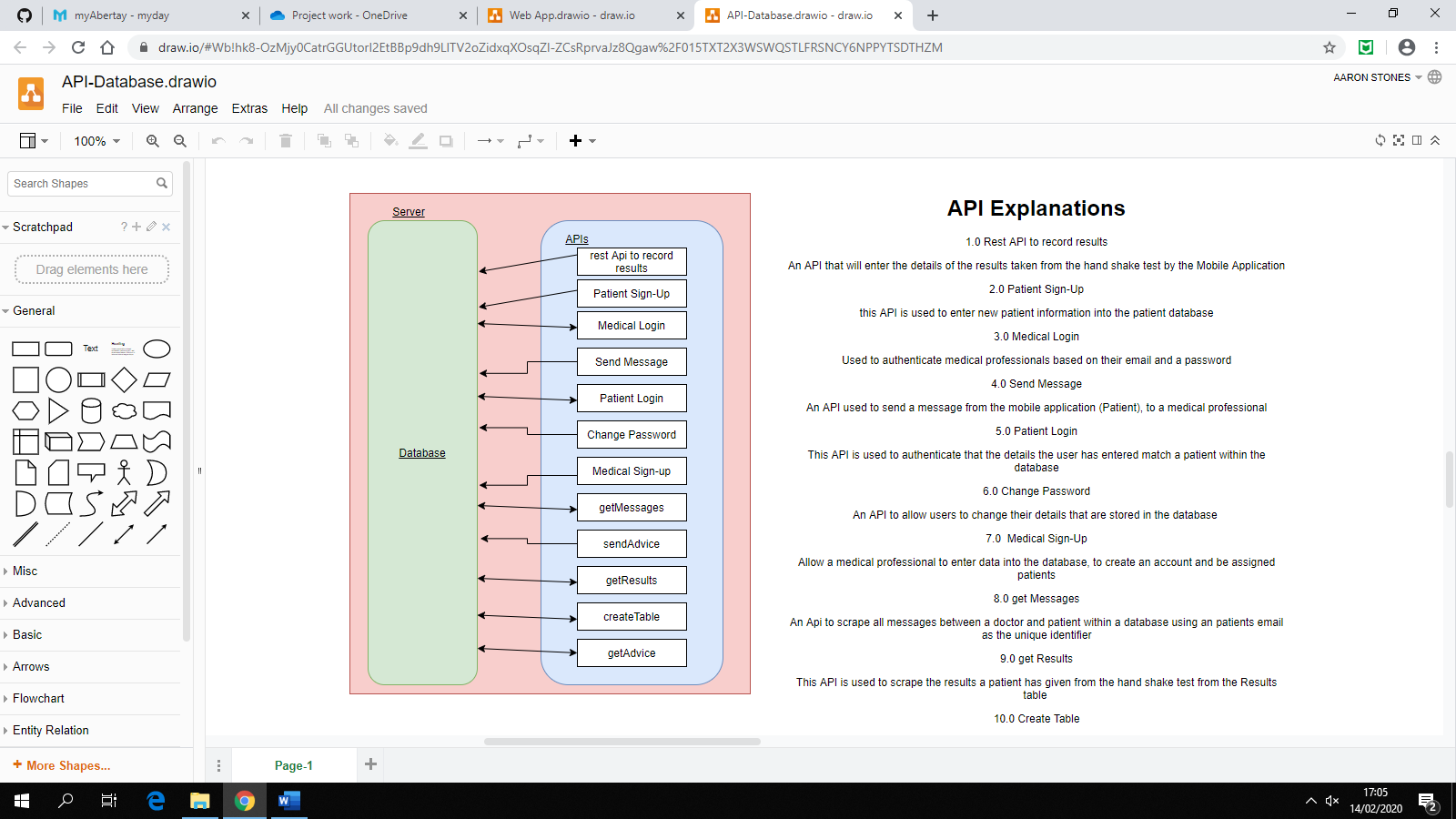




These APIs used will have to store the data in some place, the developer has decided the best place to store the data is a MySQL database. This has been selected because the type of data being stored is unlikely to change as the measurements being taken are standardised (Blood Pressure, Heart Rate, Blood Oxygen and Temperature). MySQL databases are perfect for data types that are unlikely to be changed and for amounts of types of data that are unlikely to change. So, for standardised measures of health that have been used for decades this type of database is perfect to use. Also, Abertay University provides a free to use database of this type. Relationships are the basis of MySQL databases and within this project there is no change within that. Relationships have been created to decrease the amount of repeated data within the Schema. A diagrammatical view of this has been created and can be seen below. During every reading this is taken by either, the Mobile Device or the IoT device, a new row within reading table will be created. The readings will be identified by the email of the patient and will contain the details; what Doctor the patient is registered to, the handshake result, heart rate, weight, Temperature, Systolic and Dystopic blood pressure and a timestamp (generated by the server).



The APIs will be used to communicate with this database, to store things like medial professionals’ information, results, patient information etc. A further diagram has been created to show the relationship between these APIs and the Database within the server. As shown below.



**1.0 API to record results -** An API that will enter the details of the results taken from the handshake test by the Mobile Application.

**2.0 Send Message -** An API used to send a message from the mobile application (Patient), to a medical professional.

**3.0 get Messages -** An API to scrape all messages between a doctor and patient within a database using a patient email as the unique identifier.

**4.0 get Results -** This API is used to scrape the results a patient has given from the handshake test from the Results table.

**5.0 Create Table -** This creates the php table to show a medical professional the progress of a patient, based on their results stored within the results table.

**6.0 get Advice -** Gets the advice from the advice table to show a User so that they don't forget it. Entered by the Doctor.

Neaten up this stage.

## 3.4 Implementation

### Server

The server for this application has been setup on the MySQL server using the Abertay mayar.abertay.ac.uk and PHP has been installed on this server. The server is used to access a single centralised SQL database that the three main technologies access through API’s on the server. The code within the server follows the MVC or Model View Controller development technique, which allows for the same strategies and development styles to be shared among the three devices. The creation of testing plans can be synchronised between technologies as well as they follow this development structure, again this helped in the latter stages of the project to keep a standard practice with testing and evaluating the success of this project.

### Mobile Application

To implement the mobile side of this system, details are passed between activities as JSON strings to keep data like names etc. this is done through intents and their put extra functionality. A simple login page was setup and checked through the database on the server, as well as a sign-up page. The user is also able to manipulate their account details within the mobile application through the manipulation of their data stored in the database using PHP. The user then comes to their account page, from here a user is able to, message their medical professional directly, view the advice given to them by medical professionals and perform their daily test.

The bulk of this application comes from the test a user is required to undertake; this follows the Samsung health applications functionality, where the camera is used to measure a user’s heart rate and all other data is entered by the user. During the test the rate at which a user’s hand is shaking is measured, this is done through using the accelerometer on the smart phone. The x, y and z coordinate are plotted and a threshold value is specified by the developer, if the device goes past that coordinate more than the threshold, a function called on sensor changed is called. This function adds one to a global counter to give an integer value as to how intensive a user’s hands are shaking, while a user is entering the data that cannot be taken on a mobile phone. These are weight and blood pressure, once the user has entered these values, they are redirected to have their heart rate taken. Requests are made to use the patient’s camera and flashlight; these are both turned on and the orientation is detected and set to portrait to ensure there is no discrepancies. The device’s camera is placed onto a patient’s index finger, then the data pulls out the red pixel values from a patient’s image of their finger. The algorithm uses data smoothing in an integer array to figure out the average red pixel value in the patient’s finger. The heart rate is calculated when the red pixel average is greater than the smoothed average value. The user’s heart rate, systolic and diastolic blood pressure, weight and temperature are put into POST variables and sent to the server. The Controller portion of the server receives the POST variables and passes them to the Model where they are stored within the MySQL database on the mayar.abertay.ac.uk server. Once this process has been completed a message of ‘test complete’ is sent back from the model and echoed by the Controller which is one of two results returned by this API. If the mobile application receives a ‘test complete’ response then the data entered by the user is okay and the data has been successfully entered into the database. If the Mobile Application receives a null response then the data entered by a user is incorrect and the data has not been entered into the database.

To implement both the message activity a scrolling field is used to allow the user to be able to see every message no matter the quantity. Messages are stored in a table within the database on the server, medical professionals and patients are distinguished by the Doctor column which contains a Boolean variable (1 for medical professional 0 for patient). A patient’s email is used to distinguish their message feed from another patients. Once the activity is opened the worker class is activated and a request is sent to the server for the details of the messages, this is done in PHP by and SQL (sorts the messages by the most recent message - SELECT \* from Messages where email=? ORDER BY Timestamp DESC). The results from this are returned to the mobile application, to design the messaging field the Spannable String Builder functionality is used to highlight the messages from patients in green and from medical professionals in blue with an indentation. The advice activity follows the same pattern, however, there is no need for distinction as all data is entered by medical professionals.

### Website Application

This is only to be used by a medical professional and allows the medical professionals to view data and enter new data into the database for patients to see. There are three main functionalities to the website, to give advice, to send and receive messages and view the results of the tests conducted by patients.

The processes involved with messaging and giving advice to patients, is again similar. The user selects a patient by entering their email and the previous messages/advice is shown to the medical professional for review and they can add to the advice given or send new messages.

To display the data a graphical format had been selected, to do this the free canvasJS.com API is used to plot the graphs. A graph is plotted for, heart rate, systolic and diastolic blood pressure, temperature, the handshake test integer and weight.

The graph data is populated by searching through the database for records relating to a user, using their email as an identifier. From this the data is returned from the model to the view as a json string, the web page then sends the json string to the canvasJS.com API and the API manipulates a div tag within the html already pre-defined. This setup also allowed for recursion when doing the same operations within different devices, for example the getting results functionality is used twice by both the Mobile Application and the Website Application.

### IoT device

## 3.5 Evaluation

To Test and Evaluate the software; Unit Tests, Test-Driven Development and Functional and Non-Functional Requirement Tests have been used. These were selected to ensure the individual technologies work effectively (all of their functions, classes, objects) are optimal and give the correct feedback for follow on Object Orientated structures or another technology, therefore, Unit Tests were selected as they match well with testing Object Orientated Software. Since there are three different components Unit Tests can allow for the devices to be broken down to their ‘bare bones’ and ensure that valid responses are given when they are tested with; Extreme, Exceptional and Normal test data. Since the individual components of each technology have passed the Unit Tests set out by the developer. The data within the MySQL database was monitored to ensure expected data is entered into and retrieved from the MySQL database is expected. For example, this was done through functionalities such as Login, Signup, Test Taking and the display of the results from the test taking. To ensure this project has meet the Functional and Non-Functional requirements they have been tested and functionalities screenshotted to ensure the requirements had been effectively met.

### Unit Tests

To perform these tests, data that a user can manipulate is tested, however, some of the tests have multiple parameters with data that cannot be manipulated by a user. To distinguish between data that cannot be changed a red colour has been given to those parameters and a black colour has been given to data changed by the tester.

#### Mobile Device – Java

For this data please refer to [Appendix A](#_Appendix_A)

To test the components of the mobile application, the front end (where the user enters their data) and the backend (where the data is processed) have been grouped together as they are part of the same functionality or unit.

As expected, all tests passed with only minor changes needing to be implemented to ensure the error messages read “success” or “fail” from the server. For this a more effective way of telling a user where their data had gone wrong was implemented.

#### Website Application – PHP

For this data please refer to [Appendix B](#_Appendix_B)

To test the components of the website application, the view and controller are being merged into the testing with the model, the model will be used to enter the data through a simple program and the results will be displayed to the screen.

As can be seen the results from the table show the Website Application is running optimally and returning all the correct data, as expected.

Overall, Unit Tests show that each individual component is working as expected but to gain a better understanding of how the full project comes together a System Test must be performed.

#### IoT Device - C

### Functional & Non-Functional Requirement Tests

For this data please refer to [Appendix D](#_Appendix_D)

As can be seen from the Appendix, most of the Functional and Non-Functional for this software have been met. This means that the application is ready to be reviewed to a test group to ensure that the project overall has been a success.

# Chapter 4 – Results

This chapter illustrates the results of the test group questionnaire, observational tests and further questionnaires. The participants understanding of the current state of affairs beforehand and if they thought there was room for improvement, willingness to accept this is where the research and medical practices are heading was measured before and after completing pre-determined tasks on the technologies. Analysis of the use of the three platforms and a prediction given of what the test outcomes could have been if there had not have been any interruptions to this project.

The test subject was given a background into the project and explained to that medical professional’s time could be saved through using different devices and storing data to view later.

This interview follows a structured process but after the question is asked the subject is asked to develop on a point if they feel they have something of value to add to the research being conducted.

Tasks Conducted by test group

1. Login to a pre-existing account
2. Register to the Mobile version
3. Conduct their first test and view the results
4. Contact a Medical professional
5. View the advice given to them by a medical professional

## 4.1 Test Group Results

The following results were collected from the 4 participants used in the test group. The responses to the Structured Interviews were collected and presented in graphical format below. The participants ranged in ages from under twenty, to middle aged and elderly to help with giving a better representation of each group’s thoughts and capabilities.

### Before Seeing Application

Before seeing the application, each participant was asked a few general questions about their thoughts of the use of this technology in medical practices.

The first question is to see what the subject thinks a phone or device could be used to collect data that is tedious for a medical professional to collect.

As can be seen from this first initial interview question the test group are sceptical as to whether the devices can perform the same measurements to the accuracy of a medical professional.

When querying this it was found that the main concern was not in the accuracy of the tests but in the ability of multiple user’s being able to use the technology effectively.

The next question sets out another main aim of this project which is to save a medical professionals time. The participant is asked about saving time for the NHS by reducing the number of visits and using the data provided by technology.

As can be seen from the graph the vast majority of people believe that time can be saved through the use of technology and more serious and pressing conditions can be seen to that need effective care.

One pertinent point from the discussion after this question would not to be to reduce the amount of visits a Parkinson’s sufferer would have with a medical practitioner and use this to provide more effective care for the sufferer. This point was very interesting and provides a different way of thinking about this project.

### Description and Demonstration

The background, a description of the technologies and a short demonstration of how the services communicate together was given to the test subjects. Any questions from the subjects were answered, unless they pertained to how to use the software as this is a test that will be coming up.

Overall thoughts and feelings were that the technologies selected made sense and that the project could meet the aims and objectives previously set out.

## 4.2 Observational Tests

The user was asked to perform the tests set out in the tasks to be conducted and were asked how difficult they felt each process was to complete. The tester overseen the user’s as they performed the tests and made comments throughout the processes which will be discussed after the test subjects have been queried.

As can be seen from the graph, the participants mainly found the application easy to use and could find the pertinent parts of the project fairly easy. The only bottleneck seemed to be registering, these users did not expect the length of the checks that would go on regarding their Mobile Number and email addresses.

From what can be seen the users had difficulty understanding what each page did from just the name of it. For future versions possibly a more effective naming of buttons and functionality should be used to address this.

## 4.3 Post test questionnaire

As the test has been conducted the tester wanted to find out the thoughts and feelings overall of the technology by the test subjects. The same questions asked beforehand were used again to gauge whether there was a significant change in overall feelings of the application.

### After Seeing Application

As can be seen from these two graphs the feelings of the test group have been swayed indefinitely with them thinking that this could work. The main reasons for this were as follows:

1. The quality of the results produced by the handshake test and the way in which the results are presented to the patient and the medical professional
2. The ease of use of the system and ability to get in contact with a doctor very easily
3. There is less of a hassle using this system compared to phoning their local GP surgery where the question may be put to the receptionist, then a nurse and finally to the doctor.

# Chapter 5 – Discussion

2250-2500 words

Evaluate your findings/results

Comment on their significance in relation to the previous work on the same topic

Refer to your literature review where appropriate

Use the aims and objectives outlined in your proposal/introduction if appropriate to aid your evaluation, referring to initial project requirements

# Chapter 6 – Conclusions & Future Work

750-1000 words

What conclusions can you draw from your investigation?

What are the implications of what you have discovered?

How might further work in this area be continued?

# List of References

List all works used and refer using Harvard style – CITE THEM RITE

Write references in text and add to references section while you are writing

# Bibliography

List works that you have considered but do not refer to in text. Use Harvard

# Appendices

## Appendix A

A table showing the unit Testing completed on the Mobile Application

|  |  |  |  |
| --- | --- | --- | --- |
| Test ID | Purpose | Test Data | Output |
| T001 | Using the class for interacting with the server about login functionality  accountVerification.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  Password  Type = login  **Exceptional**  owncb1234  0909838rmnowqc  Type = login  **Extreme**  [Stonesclan090@gmail.com](mailto:Stonesclan090@gmail.com)  Password  Type = login | Normal works as expected and the user is allowed to proceed, receiving their data in json from the server  Exceptional works as expected with the server rejecting the data and sending a fail message  Extreme works as expected with the server rejecting the data and sending a fail message |
| T002 | Using the class for interacting with the server about registration functionality  accountVerification.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  Password  Type = signup  Geoffrey Lund  07903459060  Aaron Stones  **Exceptional**  [stonesclan](mailto:stonesclan090@gmail.com)  osbdvods0398r  Type = signup  Geoffrey Lund@@  0790345906  Aaron Stones  **Extreme**  [Stonesclan090@gmail.com](mailto:Stonesclan090@gmail.com)  Password  Type = signup  Geoffrey Lun  07903459067  Aaron Stone | Normal works as expected and the user is allowed to proceed, receiving their data in json from the server  Exceptional works as expected with the server rejecting the data and sending a fail message  Exceptional works as expected with the server rejecting the data and sending a fail message  Exceptional works as expected with the server rejecting the data and sending a fail message |
| T003 | To get the variables from the Login activity and signup activities  Account.java  setupVariables() | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  password  **Exceptional**  owncb1234  0909838rmnowqc  **Extreme**  [Stonesclan090@gmail.com](mailto:Stonesclan090@gmail.com)  Password | Normal allows the global variables to be setup and both exceptional and extreme data fail |
| T004 | To get the advice a doctor has given to a patient  DoctorsAdviceWorker.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  No extreme or Exceptional data can be entered as this is taken from the first two tests | The advice a patient has previously received is displayed within a new activity, as expected |
| T005 | To get the messages the messages a doctor has sent to a patient  MessagesWorker.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  No extreme or Exceptional data can be entered as this is taken from the first two tests | The messages a patient has previously received is displayed within a new activity, as expected |
| T006 | To send a message from a patient to a doctor  MessagesWorker.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this is a test”  **Exceptional**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this !s @ test”  **Extreme**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “@@@@” | The Normal message is sent, as expected  The Exceptional message is both rejected by the server and the client side checks, as expected  The Extreme message is both rejected by the server and the client side checks, as expected |
| T007 | To perform the test and send the data to the server  Taketest.java  takeTestWorker.java | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  Geoffrey Lund  88  80(bpm)  96(kg)  37(degrees Celsius)  140/80  **Exceptional**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  Geoffrey Lund  88  80(bpm)  “96kg”  “37degrees”  “140/80lnkd”  **Extreme**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  Geoffrey Lund  88  80(bpm)  “96” (kg)  “37” (degrees Celsius)  “140/802” | Normal works as expected and the data is sent to the server and entered to the MySQL database  Exceptional fails with an error message being displayed in console, as expected  Extreme fails with an error message being displayed in console, as expected |

## Appendix B

A table showing the Unit Testing completed on the Website Application

|  |  |  |  |
| --- | --- | --- | --- |
| Test ID | Purpose | Test Data | Output |
| T001 | To get and send advice to a patient  **Controller**  getAdviceM.php  getAdvice.php  sendAdvice.php  **View**  advice.php  **Model**  Advice.php | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this is a test”  **Exceptional**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this !s @ test”  **Extreme**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “@@@@” | Normal data is passed from the view to the controller and passes, as expected  Exceptional is failed by the controller and passed back the same is for extreme as expected. |
| T002 | To get and send advice to a patient  **Controller**  getMessagesM.php  getMessages.php  sendMessage.php  **View**  messenger.php  **Model**  Messages.php | **Normal**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this is a test”  **Exceptional**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “hello this !s @ test”  **Extreme**  [stonesclan090@gmail.com](mailto:stonesclan090@gmail.com)  “@@@@” | Normal data is passed from the view to the controller and passes, as expected  Exceptional is failed by the controller and passed back the same is for extreme as expected. |
| T003 | To get results can be performed by a patient and a medical professional  **Controller**  getResultsM.php  getResults.php  **View**  results.php  **Model**  Results.php | **Normal**  stonesclan090@gmail.com  **Exceptional**  Stones!gmail.  **Extreme**  Stonesclan090@gmail.com | Normal data is passed from the view to the controller and the relevant data is retrieved, as expected  Exceptional is failed by the controller and passed back the same is for extreme as expected. |

## Appendix D

|  |  |  |
| --- | --- | --- |
| Functional Requirements | | |
| FREQ ID | Requirement | Success/Fail – Test cases to support |
| FREQ001 | Users must be able to register an account | Appendix A – T002 |
| FREQ002 | Users must be able to login to an existing account | Appendix B – T001 |
| FREQ003 | Users must be able to easily contact their Doctor | Appendix A – T004  Appendix B – T001 |
| FREQ004 | Users must be able to perform a test on a mobile and an IoT device | Appendix A – T007  Appendix C - |
| FREQ005 | The user must have an option to enter in readings manually that cannot be taken by a phone or IoT device | Appendix A - T007 |
| FREQ006 | Users must have a way of displaying readings in graphical format for review | Activity viewResults in the android application as well as the results page within the website application allow for this |
| FREQ007 | Users must be able to receive advice from all medical professionals based on their conditions | Appendix A – T004  Appendix B – T001 |
| Non-Functional Requirements | |  |
| NFREQ ID | Requirement | Success |
| NFREQ001 | This application will be responsive, and users will therefore be able to operate it with ease on multiple types of devices including mobiles, tablets and computers. | The website application is responsive as it uses Bootstrap, however the mobile application can only be used on Android devices |
| NFREQ002 | This application will be reliable, this will allow users to operate it with a high degree of trust, knowing that it will work as they expect it to. | The application has been tested throughout development and is known to be robust |
| NFREQ003 | This application will be scalable as it will accommodate heavier loads and large number of users. | The application makes good use of database storage space as well as storage space within a user’s device |
| NFREQ004 | This application will be maintainable by the developer, and any other teams that work on it due to its thorough documentation. | Efficient internal commentary has been provided as well as effective use of naming in classes, methods etc |
| NFREQ005 | This application will use secure practices, as it will be fully compliant with the Data Protection Act, meaning we will store the data securely and for the correct amount of time. The team will comply with the General Data Protection Regulation. | These have all been met as well as prepared statements and effective API security to ensure the application is as secure as possible |