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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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I would also like to acknowledge my family without whom I would never be where I am just now.

# Abstract

# Abbreviations, Symbols and Notation

If required

# Chapter 1 – Introduction

Within the United Kingdom it is widely reported that the median age in years is set to rise exponentially within the next thirty years. The median age currently is at forty and is set to rise to 45 within this time. This may not seem like much, but an aging population can have a detrimental effect on services like the NHS (National Health Service) as we see a rise in cases of incurable neurological brain conditions. There will be a rise in these cases because there are no known cures for them, at this moment in time, and occur in patients who are older. With a larger number of older citizens this could have a detrimental effect on the NHS. 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.

As a guideline set out by the Patient.info website, a Parkinson’s sufferer to live a quality and wholesome life, they should receive (Tidy, 2018):

* Parkinson's disease nurse specialists.
* Physiotherapy and physical activity.
* Occupational therapy.
* Speech and language therapy.
* Nutritional support

However, on consultation of the NHS website, a patient might only receive a specialised Nurse and some mild occupational therapy. It is clear from this that the NHS cannot afford to provide the kind of quality care that a sufferer needs to receive in order to effectively combat this condition.

With an aging population this situation is only likely to get worse and affordance for people to get the effective care they need to receive. New measures need to be put in place to change the way we take readings from the patients in terms of scans and nursing time, possibly with the incorporation of new emerging technologies. This has been particularly pertinent during the Coronavirus outbreak, because of social distancing and isolation of vulnerable members of society. These vulnerable members are usually elderly and as previously stated the elderly are the most at risk of developing Parkinson’s. This means that they might not be able to attend check-ups and the quality of their care would be directly affected. New technologies and conferencing apps such as Zoom have been helping to help this situation with virtual meetings being conducted and any queries or concerns being voiced to a medical professional this way.

The hypothesis for this project will follow the lines as to, can money be saved for the NHS in terms of the number of times a Parkinson’s sufferer would have to visit a medical facility for check-ups and therapy. Is it possible to collect more data from a patient to present to a medical professional from doing daily tests to provide a better insight as to the rate of progression of the disease? Also, can the use of technology improve the quality of care that is already in place and provided by the NHS.

The main aims and objectives have been displayed in [Appendix E](#_Appendix_E).

These aims and objectives will be used as a guideline to the success of this project and form the basis of the test plan and results gathering fazes to indicate a successful project.

The rest of this document is split up into five further chapters, the first of which addresses the research that will be conducted into this project before the development phase begins. The research phase has been broken down into looking at the NHS and Parkinson’s in greater depth with a look into possible technologies to help Parkinson’s sufferers. A look into the methodology behind the development of this project will occur to give an in-depth description on how to recreate this project. Followed by the results of structured interviews of people about their thoughts on the software, after that a discussion of the results and further work to be concluded.

# 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 taken from patients and how these readings are; stored, processed, analysed and displayed to medical professionals. Many of the methods used to collect data from patients have not been updated for a number of 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 Many of the processes involve substantial medical supervision. Most of these are simple readings such as Heart Rate, Temperature, Weight or Blood Pressure. Most of the readings can be taken through new technologies such as smart phones and Internet of Things devices. Smart phones contain many sensors that are able to take a plentiful supply of readings from a patient without the need of a medical professional present. 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, 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 and 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 way 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 observed, 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 managing as best, they can or if no action can be taken to benefit the patient. 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 to every sufferer at every level of severity, unless the NHS does not have the medicine or expertise to treat it at all 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) 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). 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 ever-increasing pressure on NHS budgets, 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.

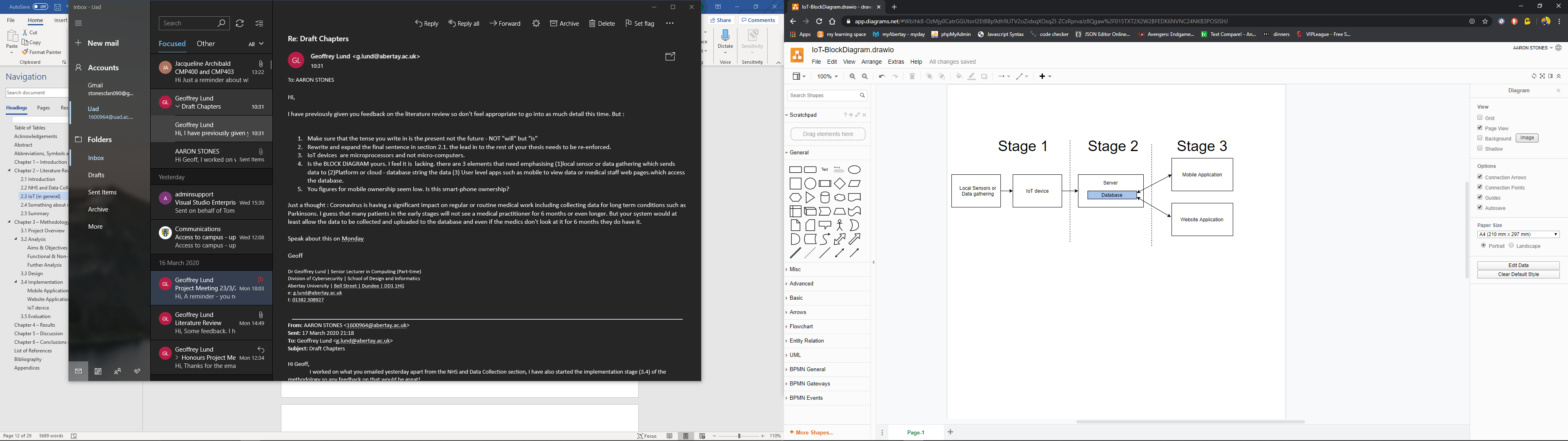
## 2.3 Micro-Processors

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 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 able to optimise the heating and cooling of homes. Or the Berennis Smart Light Bulb – allows a user to change the colour and brightness of the light through an application on their phone. There is also the 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 acting 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, reducing 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 a fall, turning on things they should not be 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.



**Figure 1 – A System Diagram, showing how IoT devices operate**

## 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 Only 55% of those over 55 own a smart phone 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 sensors which have been increasing in quality since 2014. They can also detect the smallest changes in movement, heat and changes to their locations. 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

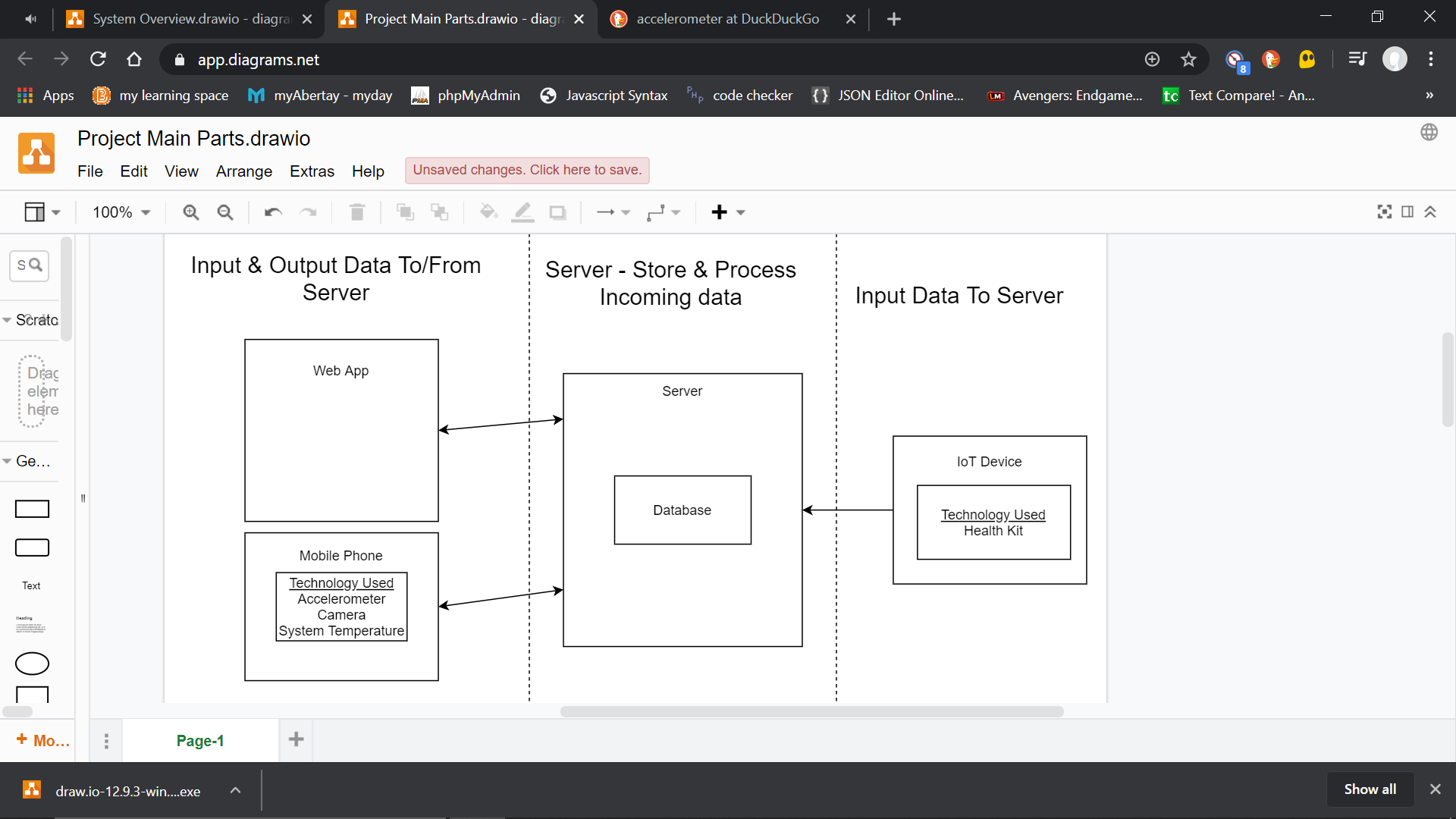
The purpose of this Literature Review was to analyse trends and common practices of technologies used within the NHS and other technologies used out with the NHS, as well as current methods the NHS utilise to manage data collection. With what has been discovered through the research conducted, IoT, smart 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.



**Figure 2 – A System Diagram, showing how the proposed system will operate**

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. |

**Figure 3 – Functional and Non-Functional Requirements**

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 various 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.

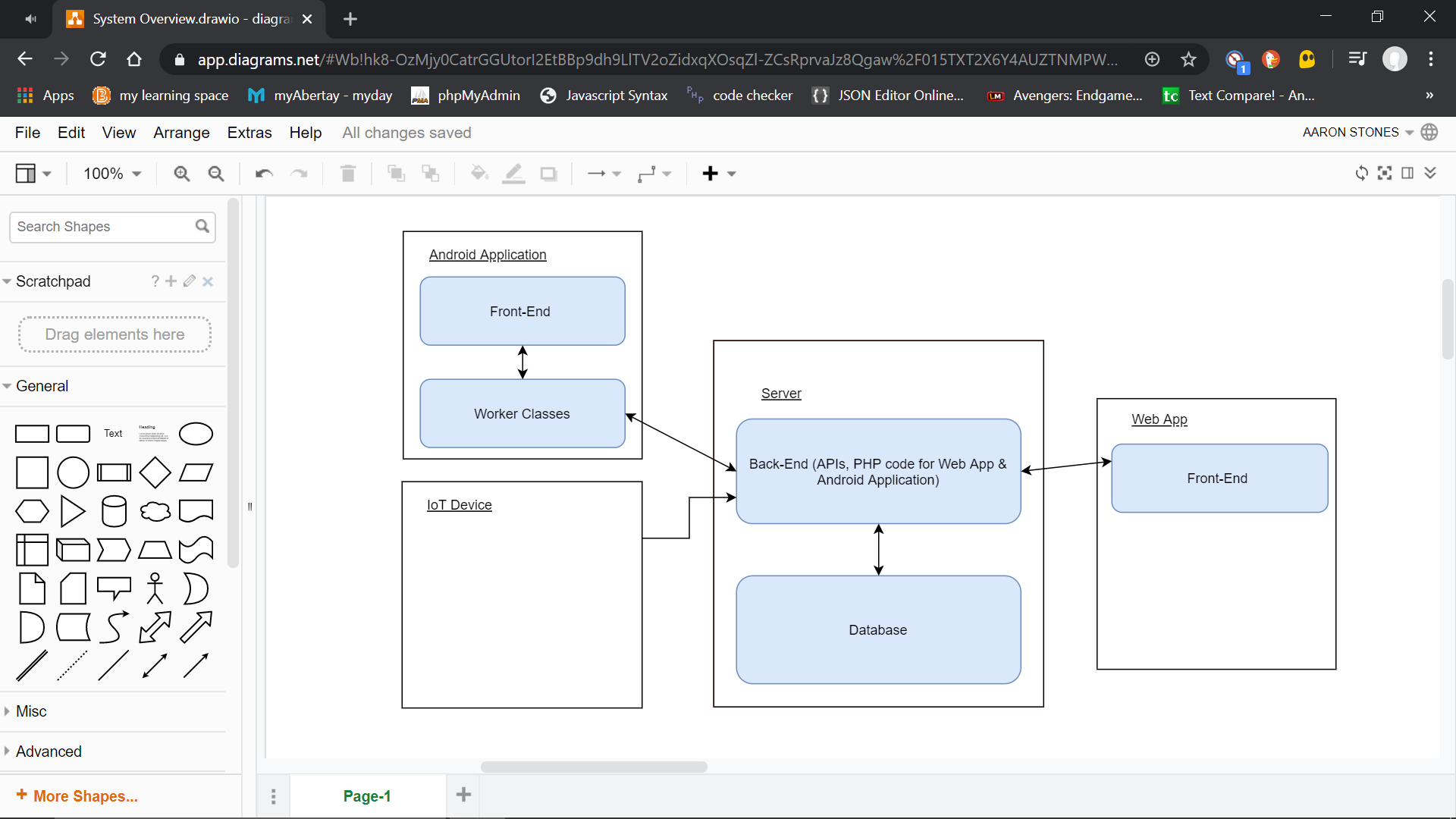
### Feasibility

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, adding their insight into what would require the most work, also giving insight into, 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.

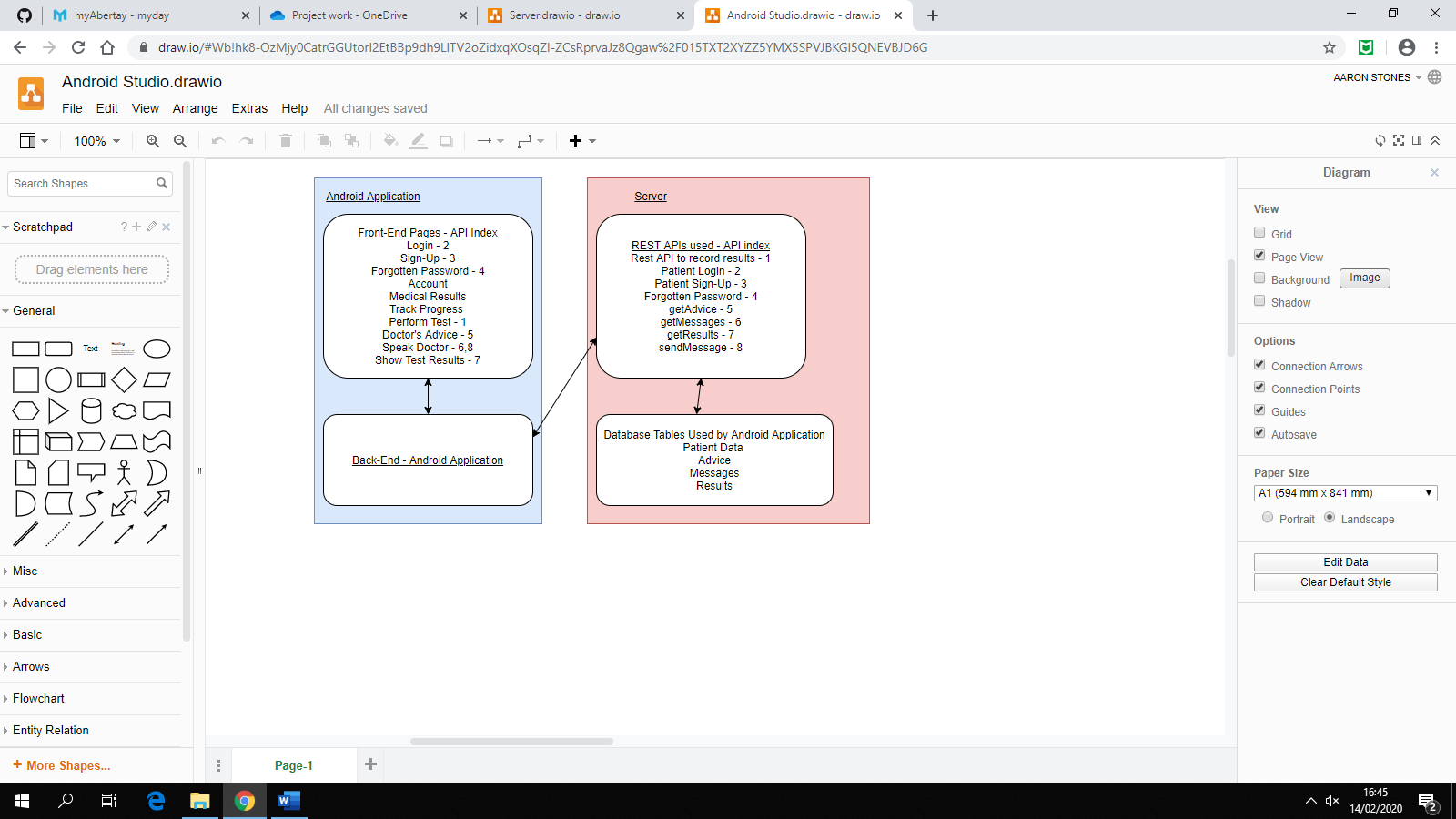
## 3.3 Design

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.

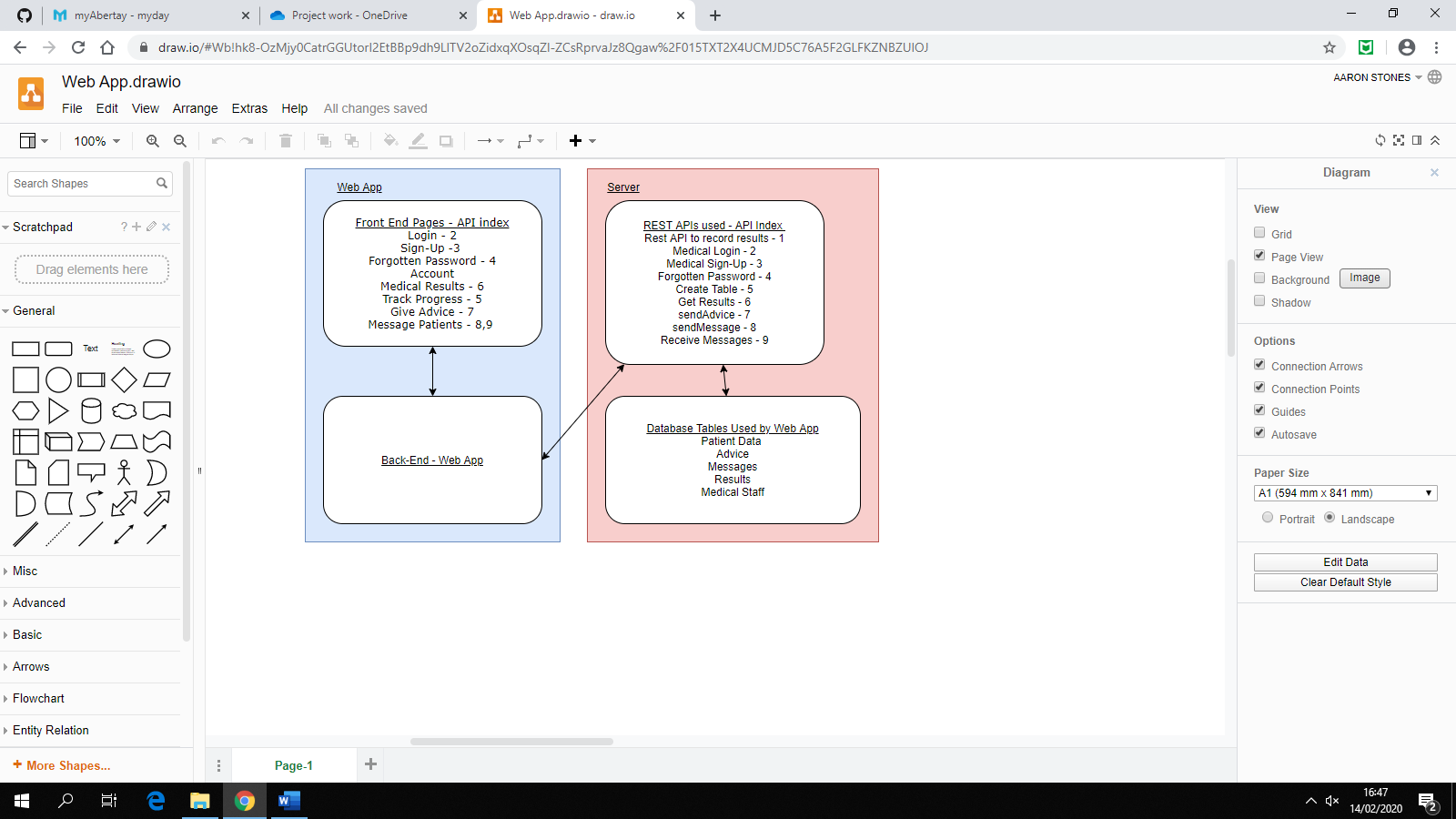


**Figure 4 – A System Diagram, showing interconnections of the system**

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.

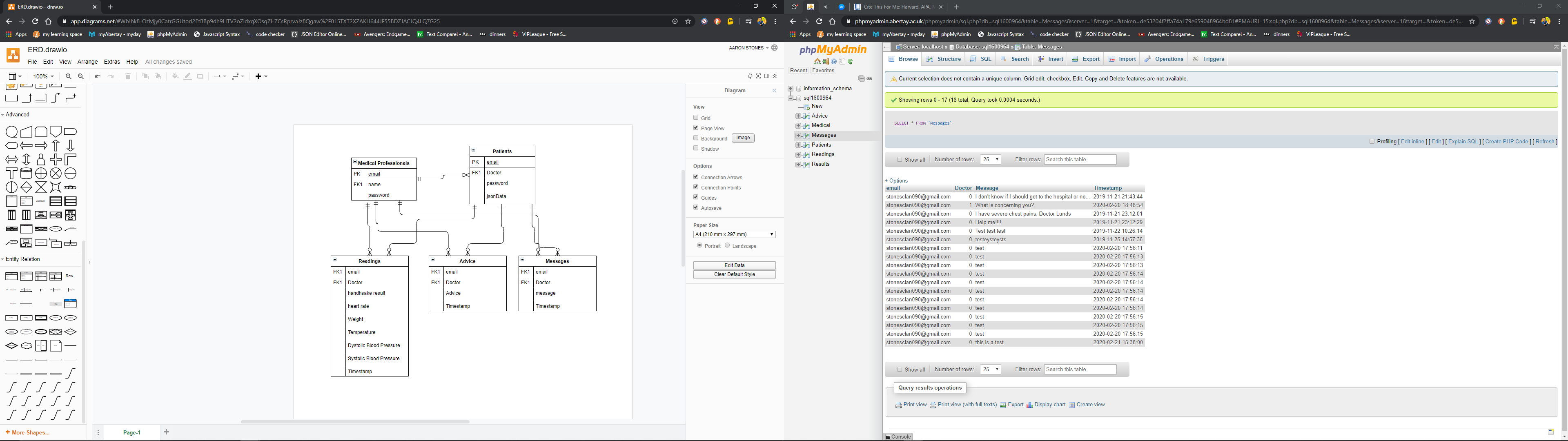


**Figure 5 – A Diagram showing the interconnection of the Mobile App and the Server**



**Figure 6 – A Diagram showing the interconnection of the Web App and the Server**

These APIs used will have to store the data somewhere, 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).



**Figure 7 – An Entity-Relationship Diagram for the Database**

## 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 conduct the test and gather details regarding the user’s physical wellbeing, to send and receive messages and view the results of the tests conducted by patients in a presentable format.

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.

### Test-Driven Development

# 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.

**Figure 8 – A graph showing accuracy question results**

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.

**Figure 9 – A graph showing medical time question results**

As can be seen from the graph many people believe that time can be saved through the use of technology.

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 interviewees. Any questions from the interviewees 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 interviewees have been queried.

**Figure 10 – A graph showing operational test results**

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 was required 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 towards the application.

### After Seeing Application

**Figure 11 – A graph showing accuracy question results**

**Figure 12 – A graph showing medical time question results**

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.

Overall, results gathering was not as thorough as was first planned. This was because of the Coronavirus outbreak and the United Kingdom being on lockdown. Ideally, the test group would’ve been of a larger size, which would have given a more quantifiable and better reasoning for the continuation of this project.

# Chapter 5 – Discussion

The main aims of this project is to use IoT and Mobile devices to improve the care received by a Parkinson’s patient, while helping to liberate time for medical professionals and assist in the reduction of the ‘bed blocking’ crisis. The system was built in three main parts:

1. The Mobile Application for Android devices that uses a simple test to record the main indicators of a patient’s health – Weight, Heart Rate, Blood Pressure and Temperature. These coupled with the phone calculating how hard a patient’s hand is shaking, gives a detailed description of a Parkinson’s patient’s health.
2. The IoT device has been designed so that a patient who does not have access to a Smart Phone can still perform the test. This device does not have an accelerometer so the handshake test cannot be performed, but can still give an accurate representation of a patient’s health, through taking a patient’s – Weight, Heart Rate, Blood Pressure and Temperature.
3. A Server was setup to allow a medical professional to Signup or Login to see the results of heir patients and so there could be a place to store the data recorded by the users. A medical professional can use this site and track how their patient’s health is through the use of the graphs plotted with their test results.

Conclusions can be drawn on the successfulness of this project with the use of the aims and objectives, the implemented solution, a discussion of the results and by referencing the literature used within the literature review chapter.

## 5.1 Aims & Objectives

The original aims and objectives can be found in [Chapter 1](#_Aims_&_Objectives), if a look into the aims originally set out in the early stages of this project, they are as follows:

1. Analyse the methods of which detection of incurable neurological disorders are carried out, utilise IoT and Mobile Devices, so a system can be developed that can be analyse and decide the best courses of action.
2. Design an effective management system that incorporates all three technologies (Web App, Android Application and IoT device).
3. Develop a system to manage the patients effectively with the three technologies.
4. Analyse the effectiveness of the system as a whole and the communication between integral parts.
5. Create an effective test plan to ensure the system is operating as planned. Test plan
6. Evaluate the hypothesis of the project using Interviews and Surveys with medical professionals and the public.

Research was conducted into these aims with section 2.2 looking into the current methods of detecting and managing incurable neurological brain conditions. This section took a particular look into the challenges faced by the NHS today, with particular interest into he specialised Parkinson’s nurses prescribed to all Parkinson’s patients within the United Kingdom. As previously discussed, the NHS is struggling to cope with an aging population and historically Parkinson’s is an age-related disease. This means these specialised nurses are few and far between, meaning that solutions are needing to be put in place to account for this.

In looking at the NHS and Data Collection, it was proposed that Smart Phones and IoT devices can be used to aid in some of the menial tasks a medical professional might have to perform. These devices can help through the use of their sensitive sensors - already built into them in the case of mobile phones.

An effective management system was designed through the use of system diagrams, to show how the system communicates. Following this, it was decided that MVC should be the development methodology that should be selected, using The university of Abertay Dundee’s setup server to host the web app and their database to store patient and medical professional data.

As stated beforehand, an effective management system that incorporates IoT, Mobile and Web Apps has been created and incorporates research conducted in section 2.3 and 2.4. In regards to utilising their already extensive services and abilities to communicate with servers easily. This also takes into account research conducted in section 2.4 where rural towns in Africa use their smartphones to send details to a medical professional who they cannot physically get to. This was implemented into the system through the medical professional’s ability to message a patient and give advice to said patient also vice versa.

An analysis of the effectiveness of the system was proposed with the unit tests, functional and non-functional requirements to ensure that these met an industry standard set out by the IEEE regulations. proceeding this, user observations and structured interviews were conducted to ensure that, users could understand and interact with, understand also operate the technologies with minimal help from the tester. This compromised an effective test plan and ensured the software was feasible through the structured interviews with interviewees.

These structured interviews aid in the ability to test the hypothesis as they give an insight into what the interviewees thoughts and feelings are in the technology as a whole and whether they could see the technology being used in a medical environment.

The use of test-driven development was integral to the success of this project, as thorough testing ensured when new pieces of technology or code were added previously coded sections would not stop functioning unexpectedly. This was one of the key objectives set out in the Introduction chapter.

External code has also been utilised, before it was utilised the code was analysed and unit tested to ensure that this code was functional and works to the developer’s satisfaction. The main parts which were utilised came in the heart rate measurements, as the developer was unsure of how to utilise the camera on a smart phone in Android Studio, as well as processing the results from the camera. Another part of code that was utilised from an external source was the basis for the accelerometer from an old ‘shake the phone’ game, this code was rigorously tested and adapted to ensure it fit with what the developer was trying to achieve (hand shake test).

Unit tests were another main objective of this project, they allow components of each technology to be broken down to their ‘barebones’ and tested to ensure they only accept and process correct data. The objective of using these has been achieved through the use of them during development and in Chapter 4.

## 5.2 Discussion of Implemented Solution

The software takes its influence from the solutions already present in the rural towns in Africa to be able to perform tests on their phones and report back to a Doctor in a large city. With a doctor being able to request more information, or give a diagnosis from their computer. Which has allowed the Doctor to see a great deal more patients.

Similar to this IoT devices can be fitted with sensors as discussed in Chapter 2.3 with the current implementations of the HIVE system to monitor a home. The basis is simple to apply a health kit to the device and monitor a patient by sending health data to a server instead of a home.

As discussed in Chapter 3 section 3.1, the use of these 3 technologies were integral to the success of this project due to the research conducted in Chapter 2.

To begin, a user would be required to signup within a mobile application, or have an IoT device setup specifically for them. A user would be able to signup through installing the software on their phone and entering an existing medical professional in the database. Once signed up the user is able to perform the tests. When the user is entering data that cannot be taken on a phone, for example their weight or temperature, the device will be monitoring how aggressively their hand is shaking. This is done through plotting the x, y and z coordinate of the mobile device. A threshold is set where if the phone goes over the x, y or z coordinate by more than the threshold a counter is updated. The camera is activated once a user has finished this and the flash turned up. This is to count the red blood cells within a patient’s finger to read their heart rate. Once this is completed the data is sent to the server to store

Previously alluded to, not all patients posses’ smart phones, this means that the IoT device will need to be setup for them, this device only has a health kit so cannot perform the handshake test. This data sends the data directly to the server and cannot be entered directly by the patient.

The website application is solely for the use of medical professionals to send and receive messages from patients, also for viewing the results of the tests conducted by the patients.

## 5.3 Discussion of Results

There were three stages in producing the results of this project, these were:

1. Gathering an interviewees thoughts and feelings from a short interview beforehand and gather their feelings on the use of technology in medicine.
2. Explain to the test subject what has been created and a short overview explaining the main features of the application. Then allowing the interviewees perform set out tasks.
3. A post-test interview to find out if their thoughts and feelings into the technology has changed or stayed the same.

During the first stage, the main focus was developing an idea as to the interviewee’s main thoughts and feelings towards the use of technology in a medical environment. What can be seen from the results is a sceptical nature towards technology, the main reasons for this is a thought of low testing quality. This has been put down to two reasons from one interviewee (others rejected the idea but were not sure why). The first of these being that:

“The technology that is present in smart phones and other devices cannot be as good as a professional conducting the test and being able to interpret the results right there and then.”

The second being related to the user’s own ability to perform the test:

“the patient cannot be trusted to give an accurate result every time, there are always different factors being brought in to try and combat this, but they very rarely work.”

These are two very pertinent points and should be taken into account when discussing future versions and the ability to negate mistakes from the client side.

Following this, the interviewees were given a short description into what the devices do and how they come together to make one complete system. They were also given a few tasks to evaluate the operational efficiency of the system (done by the tester). These tasks were:

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

During this phase of the test it was seen that the test subjects were able to move through the applications well and find what they were looking for with ease. As previously mentioned, the main struggles were with the names of different sections of the applications.

However, once the test subjects found out what they were looking at they managed to locate and complete their task with relative ease.

During the final stage of the Results phase, the same questions asked to the subjects beforehand were asked again. On reflection the test subjects were convinced these technologies could be used in a medical environment. The main basis for their thoughts was, the quality of the readings given from the test that they had completed, the display of the results on the medical professional’s website application and the ability to see advice and previous messages from doctors.

Looking at the post-test questionnaires it can be seen that there was a significant switch in how many test subjects believed this technology could not work, into people who think this technology should be deployed within the NHS just now.

## 5.4 Limitations & Improvements

The limitations of this project were mainly due to the Coronavirus pandemic, this has meant that certain essential services such as the health kit for the IoT device had to be abandoned. Although this device worked, it was not present when demonstrating the functionality to the test subjects which was a major flaw in the results phase. Also, with the Coronavirus pandemic, with all face-to-face non-essential contact being blocked the only people the tester could interview were people living inside his own home, which is not good as this could be seen as biased results. Since the tester could only interview people in their own home, a small test group cold only be consulted, this again is bad practice as a larger test group would be more conclusive as to justification for clinical trials of these applications. Limited meetings with the project supervisor were a hindrance to this project as well, more meetings with a more experienced staff member would allow the project to progress more quickly and give a better-quality application overall.

In terms of Improvements that could be made to the application, a University server is not an appropriate place to host the application. This is because the server does not allow for the same scalability that a cloud platform such as AWS or Amazon Web Services could provide. But for this early stage it is efficient enough to provide a proof of concept. The IoT device would be in-cased in something so that the board and circuits would not be visible. This would mean that if there is a spill or something onto the device, there would be less damage to the circuits and the device could possibly be recovered. Without there is very little protection for the integral parts and serious damage could be caused.

# Chapter 6 – Conclusions & Future Work

To conclude this study, it can be seen from the Results and Research conducted in Chapter 2, states that there is a need to update the way in which we care for incurable neurological diseases. The main disease identified and targeted was Parkinson’s. The research conducted, again in chapter 2, pointed to the use smart phones and IoT devices, these could mimic a normal visit to a medical professional. Through the development and usage of these two devices it was found that care and management of Parkinson’s patients can be improved. This is through the use of, smart phones and IoT devices taking plentiful readings from a patient and the use of a Web App collating the data stored in the server and displaying the data. The data needed to be displayed in a helpful fashion for a medical professional to be able to successfully interpret the data collated. The use of graphs was widely praised by the test group in Chapter 4 – Results, for the ease to see dips and improvements from patient’s health and handshake test results.

Looking at the entire application, it can be seen that the main goal was to take a plentiful supply of results to be analysed by a medical professional. This system could be utilised by patients with an early diagnosis of Parkinson’s to see how their condition progresses and if the drugs or therapy they are doing is working, or other measures need to be put in place.

As a whole, the application was built to improve patient care, with a few improvements there could be a real demand for this service within the NHS. As this service could help with the bed blocking crisis and free up medical professional’s time in the long haul.

## Suggestions for Improvements

The first improvement that could be made to this application has been previously stated and is the use of a cloud platform to store the data. Services like AWS and Digital Ocean will only charge for the computing power that is used, this would contrast systems possibly in place by the NHS of their own personal servers, that need to be maintained, powered and air conditioned. This would also improve the system through the ability to scale processing power and storage space for peak times and for the number of users in the service.

A further improvement that could be made to the system is that of a screen or cover of the IoT device, as previously alluded to a user could seriously damage the circuit board through dropping or spilling things on the device. A cover would not fully prevent the system from breaking due to these issues but would be a step in the right direction.

Staying on the topic of the IoT device, the one currently being used by the system is a Raspberry Pi Zero, so devices will be directly bought from them and they own all the IP – intellectual property – of this device and set the pricing for it. So, a report into how much this could cost the NHS could drastically change if the company manufacturing these devices decides to increase the price. To tackle this, a unique IoT device should be developed to control the IP of this system and the ability to control the pricing a lot easier.

To prove this concept Android devices were used to show that this system can function optimally. However, 60.5% of UK citizens own an Apple iPhone (Henshaw, 2019). This means there is more than half of the population being missed by producing this software for just Android devices and the system could be improved as a whole by developing a duplicate mobile application for iOS as well as Android devices.

## Directions for Future Research

Further research needs to be conducted before this system is put into a medical environment, the first that has been proposed is that of, the possibility of incorporating more incurable neurological diseases. For example, Dementia could be targeted as one of the main challenges facing elderly patients within the UK today. Studies into how it is managed and suggestions for improvement can be proposed. Following the Parkinson’s tests of this system a test to monitor the progressiveness of the disease could be created and instead of a hand shake test a memory game could be proposed since this is one of the main factors of the disease.

To see whether this system could be used within a medical capacity, clinical trials will need to take place. This could be from patients within care homes who are in early stages of the disease or, what would be suggested, from a plentiful supply of patients from varying stages of the disease to show who is benefiting the most from this system. A clinical test would also show how the system copes with an increased number of users.

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# 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 |

## Appendix E

A table display the aims and objectives of this project

|  |  |
| --- | --- |
| **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 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. | * 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. |
| 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. |