NHS Waiting Times Application

Michael Terry, Francesco Moramarco
Electronics and Computer Science
University of Southampton

Mohammed Ali Khan, Simon Bidwell
Electronics and Computer Science
University of Southampton

***Abstract*—People visit Accident and Emergency departments in hospitals and have to wait for their turn, which may take a long time. To help with this, our team has developed an open data application to show users waiting times at NHS Accident and Emergency departments and recommend ones with the least amount of waiting time. The data to show waiting times is collected from NHS weekly statistics and user reported data from our application and is further merged with richer hospital datasets. OpenStreetMap mapping tiles and the MapQuest Open API is used to present routing data to the user. We implemented a responsive web design for the application based on a two iteration design and surveyed our target audience to prove a business opportunity exists. Multiple monetisation opportunities including advertising, selling to the NHS (with a review of NHS procurement strategies) and selling the data collected with the application, are also explored.**

I. Introduction

A. Waiting at Accident & Emergency Departments

Accidents can happen anytime and to anyone. They are unexpected and can range from being harmless to life-threatening. In any sort of such accidents and emergencies, one must visit a hospital, specifically the Accident & Emergency department. While in immediate emergencies, people are attended to much quicker, the more general emergencies require waiting for one's turn. This may vary dependent on the amount of patients present and other availability factors. This means that a person could be waiting for treatment for as little as half an hour or more than five hours. A long wait is definitely stressful and is more likely to be even more so when a person is in a state of pain or discomfort. Long waiting times are currently a problem in the NHS. The current goal is that 95% of patients at A&E must be seen within the first four hours. However, at the current time, this target is not being met[1] – in fact, A&E wait times are at their worst in a decade[2]. This means that more patients have to wait longer at A&E which is far from ideal. Another problem is that if patients will visit hospitals which are already crowded, they will add to the waiting time, thereby decreasing the efficiency of the hospital.

B. Solution

The NHS publishes the data it collects on A&E admissions with regard to waiting times and other hospital attributes. This means that it might be possible to use this data and find the hospitals with least amount of waiting times or highest patient discharge within the first four hours. If a patient needs to visit A&E and they have a choice of more than one hospital to go to, it would be possible for them to go to the one with the least amount of waiting time. This would mean that they are treated quicker than usual and also mean that the load on hospitals might be balanced better. To implement this, we have created an application which allows the user to put in their location and use it to find the hospitals nearby. It then checks which ones are close and have shorter wait times and recommend these to the user. Other factors could also be taken into consideration and the user can then select the best hospital for themselves using their own preferences.

II. Background

A. NHS A&E

NHS Accident and Emergency departments should be visited in genuine life-threatening instances such as loss of consciousness, persistent chest pain, breathing difficulties etc.[3]. Such departments at hospitals offer a 24-hour service but may not be present at all hospitals. The Department of Health introduced a four-hour target for A&E department of NHS hospitals[4]. The initial goal was that by 2004, 98% of the patients visiting A&E should be dealt with (seen, admitted, treated or discharged) within the first four hours. This target was not met by 31 Decemeber but in 2005-06, 98% patients were seen and dealt with within the first 4 hours. However, in 2010, this was revised to 95% [5] since the 98% target was deemed to not be clinically justified. The target system itself has had mixed reviews, with those who think it has been successful as the performance of English hospitals has improved in comparison to other national health services[6]. However, there is also opinion that targets have done more harm than good, as the focus is now meeting the target and with the application of 'dubious management techniques', the patient ends up being overlooked or not treated correctly [7]. There is also argument that basing A&E policy on a single criterion would not be helpful either[8]. The different reasons for not reaching the targets are because of lack of personnel, beds[9] , small departments and delays in access to diagnostic services. Moreover, further research also seems to show an increase in older patients and hence long-term conditions as well as extreme temperature, which coupled with peak time crowding is putting great pressure on the A&E units and the ageing and population growth will stretch these departments even more [10].

B. Surveys

In order to confirm the need for a concern about this specific problem, it was deemed necessary to interview a random sample of people. A survey form was created and an ethical request was submitted through Ergo[1].

[1] https://www.ergo.soton.ac.uk

Given the nature of the problem, it was decided that the target audience should be formed of people from a wide age range (18 to 60), who are likely to use a smartphone in their daily life. The surveys were sent through the internet to people from a number of different location in the UK and 70 responses were collected. The data was stored anonymously.

The surveys were composed of two parts. The first part aimed to investigate about the subject problem. In particular, it asked whether the people interviewed ever had to go to the Accident & Emergency department of NHS, whether they had a choice of different hospitals to go to and information about the waiting times they experienced. The answers collected were analysed and the results visualised (Fig 1) served to justify our concerns and prompted a need for a solution.

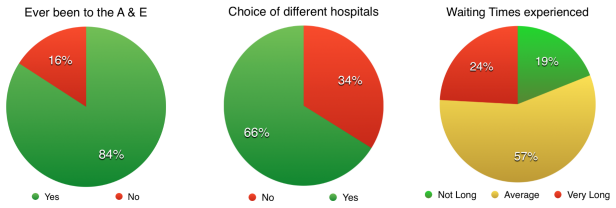

Fig. 1. Survey Results

The second part of the surveys aimed to gather opinions from the audience regarding our proposed solution, including additional services they might like to have and potential issues.

The textual answers to these questions were pigeonholed and ranked by number of occurrences. The most popular ones are reported below:

Occurrences	What services would you like to see?
26	directions to the hospitals and travel time estimate
15	what services are available at which hospital
12	rating of hospitals and reviews by the patients
7	users sending feedback of the current waiting times
3	live updates from the NHS trusts

Occurrences	Can you think of any challenges or issues
28	difficulty in estimating waiting times and legal issues
16	Not many hospitals in certain places
9	people with serious injuries might not think of using the app

Fig. 2. Users Opinions

Each of their suggestions were taken into consideration when designing and developing the final solution.

C. Existing Solutions

1) NHS Hospital Finder: The NHS's own internal solution to find hospitals. Not specifically aimed towards accident and emergency but instead at all hospitals. A user can enter their postcode and find nearby hospitals, they can see what facilities are available at those hospitals, how to reach them and statistics about hospital quality. However, the user has no idea how long waiting times for accident and emergency will be, which was the highest priority for our surveyed users. And the statistics are not specific to accident and emergency but cover the entire hospital. In addition it does not support geolocation meaning the user has to manually type in their location.

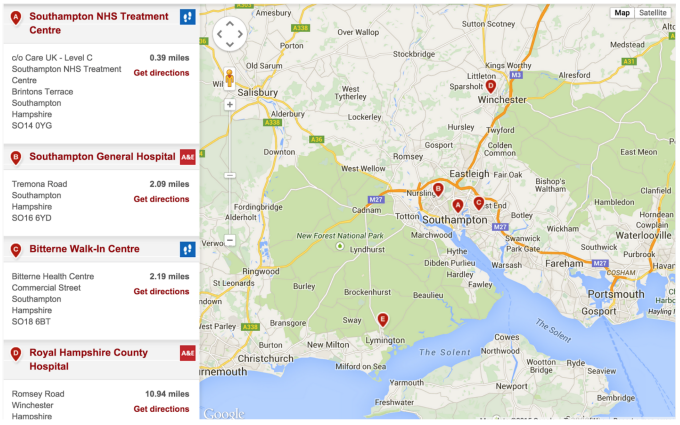

Fig. 3. NHS Hospital Finder

2) BBC Weekly Accident and Emergency Tracker: The BBC tracker takes weekly open data from the NHS with accident and emergency statistics and displays them to the user. Whilst users have a limited idea of expected waiting times due to the application showing the percentage of users seen within 4 hours for the last week, it has no more detailed or recent data on waiting times. In addition most statistics displayed are not adjusted for hospital size, so a user cannot judge the probability of an issue affecting them. For example it will show the total number of beds blocked but this number will tend to be higher for larger hospital.

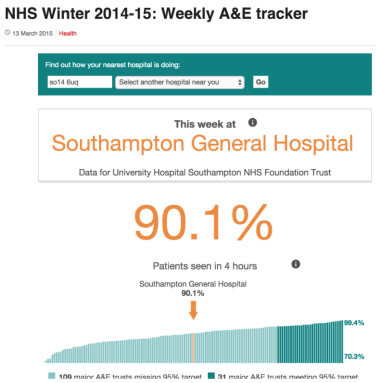

Fig. 4. BBC A&E Tracker

III. Design & Implementation

A. Design

The first design decision that had to be made during the project was regarding the form factor we would use for the application. The application could be developed for iOS, Android, or for the web, and each option has its own positives

and negatives. Developing for iOS or Android would mean the application would have the reduced loading times associated with a native application, and could also be featured in each operating system's respective application market. However, developing a native application for a mobile operating system means that a fee needs to be paid to publish the application, and the application will only work in that ecosystem. Developing the NHS Waiting Times application as a single page web app would mean that there's no installation for the user, the solution can be cross platform, responsive design allows the application to run on desktop and mobile, and there's a large variety of libraries available to allow quick prototyping for a web application. Despite the lack of application market and the marketing benefits that come with it, it was decided that designing the NHS Waiting Times application as a single-page, responsive web application best suited the requirements of this project.

After settling on the form factor for the application, wireframes were created to begin prototyping the look and feel of the product. The wireframes featured a simple homepage asking the user to press a button to locate them, a list view and a map view. The list view showed all the nearby hospitals in a list, and the map view displayed all the nearby hospitals and the users location on a map.

Fig. 5. Mobile Wireframes

Due to the quick prototyping nature of web applications, the wireframes were used to create an initial implementation of the application which was then used to gain feedback and iteratively improve the design of the application. The second design of the application implemented a blue and white colour scheme, similar to that of the NHS and combined the list and map view into one view as seen in Fig 6. The list and map view were combined into one page because it was felt that both views served the same purpose and having two options was confusing to users and led to an unintuitive user interface. To make the new combined view responsive to mobile viewpoints, the list on the left automatically collapses under certain resolutions and can be opened at the press of a button. The new blue colour scheme and combined pages were found to be an effective user interface design for the application, and very few changes were made between the design and the final implementation.

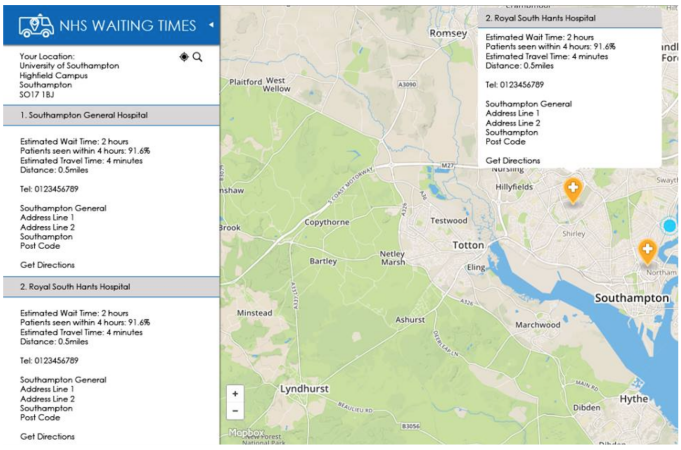

Fig. 6. UI Design

We decided to implement our application as a single page web application because:

- Can be deployed as a website so no install for the user
- Cross platform
- Using responsive design same application can run desktop and mobile
- Allows quick prototyping
- The group is experienced with web development
- Large variety of libraries for web development

B. Implementation

The first screen of the application supports finding your location using the HTML5 geolocation API. If a user does not want to do this for privacy reasons, they can instead type a place name in and we find a location using geocoding from the MapBox API.

Upon finding a location, the user is shown the map screen (built using MapBox OpenStreetMap tiles) showing nearby hospitals as markers. The user can click on a hospital marker to see a bubble showing vital hospital statistics. The panel on the left shows the available hospitals which can be scrolled through and also show vital hospital statistics.

We made the application a responsive design of one codebase for desktop and mobile with the elements changing size and design depending on the screen size. For example, on a wide screen the hospital draw is shown on the left but on a narrower screen such as found on a mobile phone it is hidden to be revealed using a hamburger button. Because we built our controls using the bootstrap framework they automatically resize depending on screen size.

Figure 7 and 8 show the finished desktop version of the prototype.

Fig. 7. Desktop Home Screen

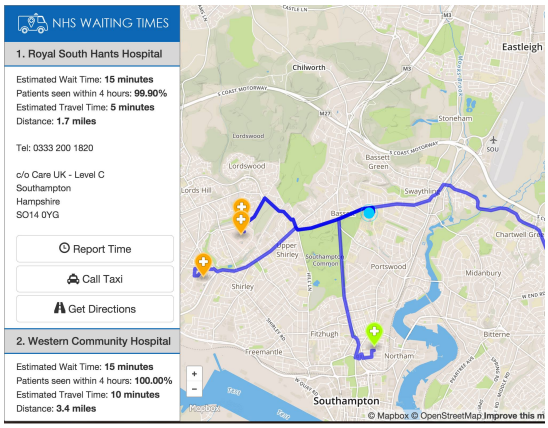

Fig. 8. Desktop Main Screen

Figure 9 and 10 show the finished mobile version of the prototype.

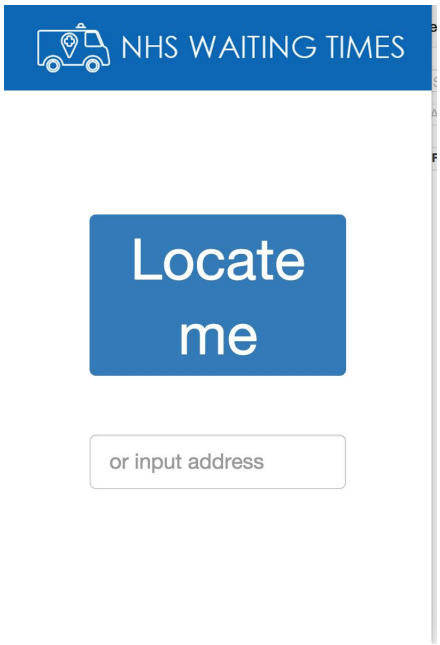

Fig. 9. Mobile Home Screen

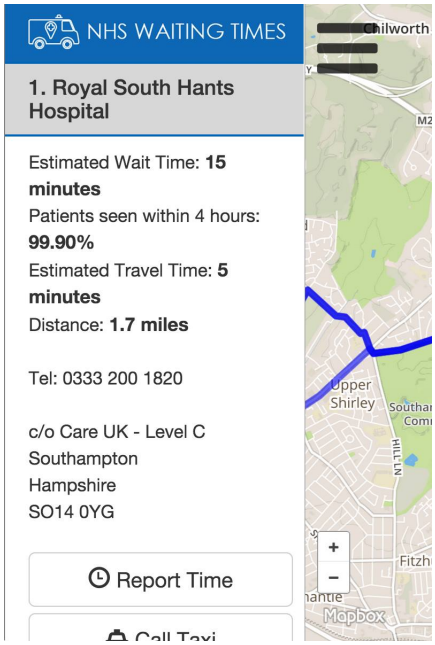

Fig. 10. Mobile Slide up Panel

1) Libraries: The following were used to implement the prototype application.

Bootstrap [11] – popular CSS library used as styling for buttons. Also, as a responsive library, buttons will automatically resize as screen size changes.

slideout.js [12] – implemented using CSS transforms to allow for GPU acceleration and used to implement the slide-out panel on narrow screens. It supports dragging but this was disabled as it would conflict with dragging the map.

jQquery [13] – common client side scripting library, used for Ajax queries, DOM manipulation and traversal avoiding the kludgy inbuilt browser API.

Leaflet.js [14] – lightweight Javascript mapping library. Only 33kb in size and mobile friendly with good plugin support.

MapQuest leaflet routing plugin [15] – automatically plot a route from the open mapquest routing service onto a leaflet map

Mapbox.js [16] – plugin for showing Mapbox open-streetmap tiles on a leaflet map. In addition supports mapquests geocoding service.

Alertify.js [17] – simple extensible javascript library for displaying custom alerts. Used to show errors and the time picker dialog. Uses responsive design

2) Cross browser Testing: We tested against the following browsers. To run cross browser testing we ran a simple test script involving finding a hospital via either geolocation and geocoding.

Target	Passes
Mobile Safari, IOS 8.3, iPhone 5s	YES
Chrome, OS X 10.10.3	YES
Chrome, Android 4.4, samsung Galaxy S4	YES
Firefox 37.02, OS X 10.10.3	YES
Internet explorer 11, windows 7	YES

C. Open Data

1) NHS: NHS, being a public health service, tries to be as transparent as possible. Because of this, they make large amounts of rich data available to the public. Therefore, we were able to retrieve numerous datasets regarding A&E.

First and foremost was the weekly published A&E data [18]. This contained details on each NHS Trust, showing the amount of patients in A&E for the current week and also dividing them into different types of emergencies (Ambulance or walk-in). This also displays the percentage of people which were admitted, transferred or discharged within the first four hours.

There also exists quarterly published data on NHS Trusts which provides more specific details on the A&E patients[19]. This contains median times to initial assessment, treatment as well as total time spent in A&E. All the median times are available in minutes.

We also have data on hospitals themselves. This means their names, parent organisations (Trusts), location (address, postcode, latitude, and longitude), contact details and hospital type [20]. Moreover, the NHS Choices sector also releases another dataset on hospitals which contains a great deal of information about hospitals. This dataset gives us the percentage of people dealt within the first 4 hours for each hospital, recommendations by friends and family, inspector quality ratings and cleanliness ratings amongst others [21].

2) OpenSteetMap: OpenStreetMap [22] is a map of the world, created under a free licence. This gives us the ability to display a map in our application and also locate numerous different places. It also has numerous APIs built on it which are helpful to us. One such API is the MapQuest API [23] which is able to give us directions from one location to another as well as drawing a visual path on the screen.

3) Data Cleaning and Manipulation: After collecting the data, we had to convert some of the .xls files into a .csv format to allow for easier parsing and processing. This meant clearing out the unnecessary cells and information. We also used OpenRefine to try and filter out duplicate records, where applicable, multiple representations and spelling. Moreover, some of the data was entered in the wrong columns and Excel was used to move the values around.

4) Datasets Merging: In order to insure a clean and fast processing of the datasets in the application, we created a python script that automatically merges two data sets, filtering out unnecessary information. In particular, the dataset containing weekly statistics on the NHS waiting times was joined with the dataset containing detailed information for each hospital (including address, contacts, geolocation).

IV. Analysis & Evaluation

A. Application Feedback

After designing, developing and testing our interactive prototype, we have prepared an evaluation survey to test the key components of the app with our target audience. The anonymous interviewed people were asked to use the working prototype and answer a few questions regarding their experience.

The data gathered can be visualised as follows:

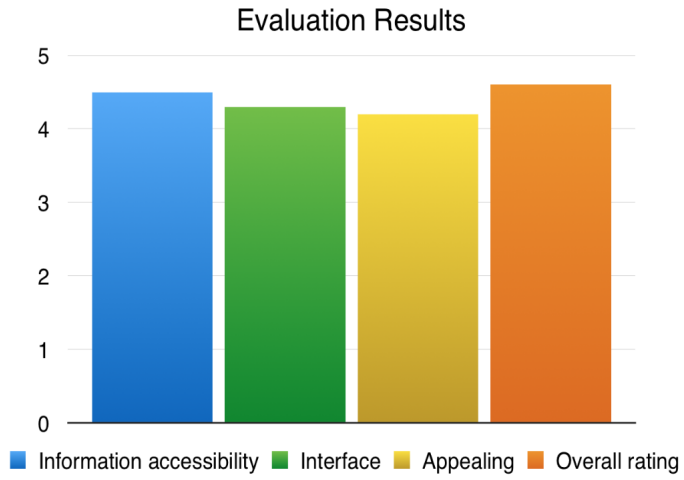

Fig. 11. Application Feedback Average for each question on a 0 to 5 scale

Textual information, including issues and improvements, were categorised and ranked by number of occurrences. The most frequent ones are reported below:

Positive aspects
Information displayed: waiting time, routing, contacts
Easy to use and understand
Clean appearance, fast processing

Issues
Safari mobile compatibility
Need to redirect to home screen with back button

Improvements
Public transports routing information
Live traffic information

Fig. 12. Users Feedback

The audience suggestions have been taken into consideration and will be added in the next iteration.

B. Project evaluation

As part of our group management process, we scheduled to meet once every week, with agendas and minutes to keep

track of the project progress. We used online videoconference tools such as Skype and Google Hangouts during the Easter break.

A number of tools were used to insure a smooth storage and transfer of the code and documents produced, including GitHub[2] and Google Drive. Facebook groups, chats, and events were used for quick communication and meetings organisation. Emails were used for any other type of communication.

A project schedule was created from the beginning and enforced with the use of a Gantt Chart, which is summarised below.

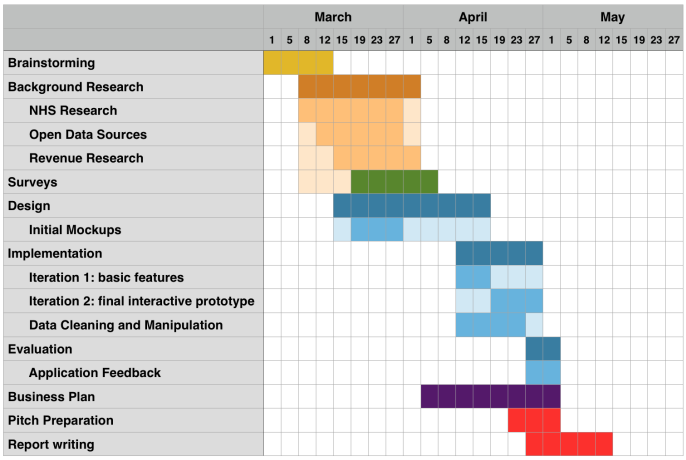

Fig. 13. Gantt Chart

V. Business Plan

Section I identifies a problem and proposes a solution, the surveys discussed in Section II-B establish that there is a market for such a solution, and the proof of concept discussed in Section III-B proves that the concept is feasible. Therefore a business opportunity exists.

A. Monetisation

It was determined that there are three possible monetisation models that could be used to generate revenue for the NHS Waiting Times application as a business: the application could be sold to the NHS, data generated by the application could be sold to the NHS, or the application could show advertising to its users.

1) Selling the app to the NHS: The NHS National Program for IT (NPfIT) was set up in 2002 and intended to run for 10 years [24], it aimed to provide centralised patient records for the whole of the NHS. NPfIT was a massively complex project integrating data from a vast array of NHS trusts with complex contracts complicating matters further, and it cost over 10 billion before being scrapped in 2011[25]. The NPfIT is an example of an IT project over the whole of the NHS and the problems encountered meant the project has been seen as an expensive failure, leading to the NHS reverting to trust-level procurement of IT contracts[24]. That is, local NHS trusts are in charge of their own IT projects, rather than there being large projects for the whole of the NHS.

Trust-level procurement is seen as an opportunity for smaller businesses to work with the NHS but its process makes selling the NHS Waiting Times application to the NHS difficult. To tender a new project, all Public Sector organisations have to abide by The Public Procurement Regulations 2006 which is the law that relates to procurement and is common to all European member states. This means all NHS trusts are obliged follow a defined procurement process. In total there's 6 stages [26]:

- Advertising - listing procurement opportunities in the Official Journal of the European Union (OJEU)
- Expression of interest - suppliers show they're interested in bidding for an opportunity
- Selection - suppliers are chosen to bid for a contract
- Invitation to tender - suppliers bid for the contract
- Evaluation - the suppliers offers are judged
- Award - the preferred bidder is selected

The rules ensure that the tendering process is open and fair. Unfortunately, this also means that, unless an individual NHS trust advertises a contract for a product similar to the NHS Waiting Times application, the application cannot be sold to the NHS. The NHS Waiting Times application has identified a problem and solved it, the NHS tendering process identifies a problem and then asks for suppliers to propose a solution. Until NHS trusts identify the same problem that the NHS Waiting Time application intends to solve, it cannot be sold to the NHS through the procurement process. However, if an NHS trust ever does advertise a contract for a product similar to the application, it could be sold or licensed to that trust to generate revenue.

2) Selling data to the NHS: When using the NHS Waiting Times application, users are encouraged to supply the application with their waiting time at the A&E department they visit. This data is used by the application to generate approximate wait times for different A&E departments, and in theory can also be used to track the performance of a department.

The data submitted to the NHS Waiting Times application would allow live-updates of the waiting time at specific A&E departments. However, as seen in Section III-C, NHS trusts already track the performance and waiting times of their A&E departments, although the exact granularity and detail of this tracking may vary. The possibility of selling the data generated by the NHS Waiting Times application to the NHS cannot be ruled out, there is the question of how many NHS trusts would find this data useful. As such, more research needs to be carried out to determine the feasibility of and the interest in this potential revenue stream.

3) Advertising: A report by NHS Innovation South East[27] detailed the different monetisation opportunities for Health applications - paid, freemium and advertising. The report found that the freemium business model does not seem to align well with health orientated applications and that although paid applications can generate more revenue, the business model can act as an entry barrier. Although there

[2]https://github.com

is no single commercial model relevant for health orientated applications, it seems that advertising is the most fitting for the NHS Waiting Times application.

According to open data released by the NHS, there are approximately 440,000 A&E admissions every week [28]. 100,000 of these admissions are emergencies, but that leaves 340,000 non-emergency admissions every week. Extrapolating that figure to a year gives almost 18 million non-emergency admissions to A&E, all of which are the target audience for the NHS Waiting Times application.

When using the NHS Waiting Times applications, users provide their location. From this data we can infer the fact that they wish to travel to a hospital in the near future. This information coupled with information provided by user cookies and profiles allows highly targeted, contextually relevant adverts to be used to monetise the application.

The location of the user is particularly important for the direct advertising planned to be implemented into the NHS Waiting Times application. For direct advertising, the NHS Waiting Times team will directly partner with companies placed near hospitals or transport firms in the areas around hospitals, and then display adverts for those partners when a user in their area uses the application. Another form of advertising to be implemented in the NHS Waiting Times application is affiliate programs. When the application is used, it is safe to assume the user is in location A and would like to travel to hospital B. It is possible to generate a booking link for ridesharing and taxi firms from A to B for the user, and through affiliate programs, if the user makes a booking through the NHS Waiting Times application, the taxi and ridesharing firms will share some of the profit generated by the booking with the NHS Waiting Times application. Although direct advertising for every location is the ideal situation, sometimes it won't be possible, so to increase the fill rate of the NHS Waiting Times application and to ensure some advertising is always shown, a mediation service such as DoubleClick mediation will be used to provide fallback advertising. A mediation service will first serve up the direct adverts if applicable; if not, it will allow advertising agencies (such as AdSense) that the NHS Waiting Time app is registered with, to bid to show an advert to the user.

4) Costs: The NHS Waiting Times application is relatively lightweight and as such, there are few costs involved with keeping the business running. The prototype created over the course of the last few months is robust and nearly ready for the market. An estimated two months development time is needed to polish the application and implement the feedback from the target audience detailed in Section IV. Only two employees are needed by the business: one will be in charge of finalising the development of the application and the following maintenance while the other will be in charge of creating the strategic advertising partnerships described in Section V-A3. The employees can be paid in equity to reduce costs. As well as employees, another running cost for the NHS Waiting Time application is servers. Servers are required to host the application so that it can be visited by users, but due to companies such as Amazon Web Services, website hosting costs are minimal. Finally, to help the application find a market, advertising is an important tool. Fortunately, the NHS provides a health application library [27] which can be used to both gain approval from the NHS and to advertise the application free of charge.

VI. Conclusion

The team was created at the start of March and chose to tackle the problem of long waiting times at A&E departments in hospitals. Research conducted showed that the NHS had a problem with waiting times, having failed to consistently meet their set targets. Moreover, surveys with people suggested that there is room to produce an application which can recommend nearby hospitals with lesser waiting times. NHS data regarding hospital locations and A&E performance was retrieved and combined with other information such as hospital ratings to provide comprehensive details about each hospital. This was then plugged into a simple application which allowed the users to enter a location and recommend them a hospital. This application was also reviewed by numerous users and they gave positive feedback on the application.

A. Assessment of Solution

From the above discussion, it can clearly be seen that the problem described in the introduction has been tackled well by the NHS Waiting Times application. The application has the ability to locate the user and also allows the users to put in their location. Once the location is provided, the application finds the three hospitals nearest to the user and suggest the one with the least amount of waiting time. It also estimates the time taken to reach the hospital, the time the user might have to wait as well as presenting care quality ratings. No planned feature for the prototype has been left behind, which leaves room for future improvements from feedback and other plans.

B. Future Work

This application has great potential but there are still additional services and features which can be added.

1) Other modes of transport: Currently, the application only takes into consideration the travel time taken by car. However, this may not always be the case as people who are not in an extreme emergency might want to either walk, bike or take public transport like trains or buses. In such a case, it would be useful for our application to calculate time from other modes of transport as well as including directions with public transport choices using the timetable data available[29], thereby increasing utility to users without cars.

2) Traffic Data: Similar to live-updates of waiting times as hospitals being more useful than static, weekly ones, live updates to travel time taking traffic into consideration is also immensely better. This would allow us to give better recommendations of hospitals since one hospital may have little wait time but also have lots of traffic on its way. Moreover, we may also give better directions by manoeuvring around the dense traffic areas to ensure the users can reach their hospitals quicker as well as waiting less. Traffic data is available for all over Great Britain[30].

C. Reflection

Over the course of a month and a half, the team was quickly formed and brainstormed well to come up with an innovative idea to implement into an application and help users choose hospitals with lesser waiting times. The team then effectively divided tasks and worked extremely diligently to design, research and implement the application. The application created had a clean and simple interface and was well-received by those who tested it out; barring minor improvements, it has been considered a good application. The team itself has also gained valuable experience as entrepreneurs and better understand the process of quickly establishing an idea. The good reviews for the application, coupled with a solid business plan, give the application great potential. And with little work left to tweak the excellent prototype into an excellent product, this has can be considered a successful utility hopefully in use by people for numerous years to come.

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