

RESEARCH PROPOSAL

Ewan Richards (1802187)

UNIVERSITY OF WALES TRINITY SAINT DAVID Research Methods and Professional Development
(ACFA7004) – MSc Software Engineering, School of Applied Computing

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3 Title

The working title of the project would be: Investigating Bluetooth and Beacon Technology to aid University building tours.

4 Introduction with Background to the Proposed Research

New students to any university feel anxious about starting in a brand-new establishment which they are not familiar with.

The research aims to look at how Bluetooth and Geographic Information Systems (GIS) can be used to implement a self-guided tour app as well as look at the type of technologies that are typically used for this type of application.

The organisation being investigated is the University of Wales Trinity Saint David (UWTSD). UWTSD operates many campuses across Wales and England. As a university, it has thousands of students within it many of which are new students to the university. Inductions are usually carried out within the first few weeks of the students being at the university with tours typically conducted however, some students may want to walk around the building outside of induction time but still require some assistance to orienteer themselves with the campus. The UWTSD self-guided tour app allows students to orienteer themselves with the campus building and give the information required, such as opening times, and provides locational information of where they currently are within the building as well as information about the specific room or department, they are near. This would assist with students finding their way around the campus independently so then, as they become more familiar with their surroundings using the app, they can then walk around the campus by themselves without the app.

By the end of the project, it is expected that the user will be able to walk around the UWTSD IQ building with a web application on their mobile device, once they reach a particular Bluetooth beacon the app will inform them where they are and inform them whether they are nearby any specialised rooms or labs. If they are located at a particular room of interest, such as Student Services, it will inform the user of the type of support that can be provided by the University.

5 Aims & Objectives

The aim of the project is to build a university tour web application for the UWTSD IQ building which utilises GIS and Bluetooth to provide the user with locational information.

The objectives of the project are:

1. To research the use of GIS and Bluetooth for providing locational information.
2. To research two similar apps to see how they work as well as the technology that is used for the apps to work and analyse the user interface.
3. To choose a route on the ground floor of the IQ building at UWTSD and pick three locations on the ground floor of the IQ building with basic dimensions of the rooms to be collect.
4. To find three suitable beacons and any supplementary equipment needed.
5. Set up three beacons at the locations and test to ensure that they work.
6. Build the application using C# and collect user feedback.

6 Literature Review

6.1 Physical Web

The physical web finds web pages linked with a particular location and is controlled by Bluetooth beacons. Many different internet browsers on mobile devices can display the URLs. [1]

The physical web allows for quick interactions with actual locations. By using the physical web, users can interact with any location and an interaction is just a touch away. A benefit of the physical web is that any information and locations can be broadcasted via this platform. The physical web ready URLs being shared any item that can be read via a Bluetooth Beacon will be broadcasted. Internet browsers, such as Google Chrome, can show URLs after going through a proxy. [2]

Google Physical Web : how it works

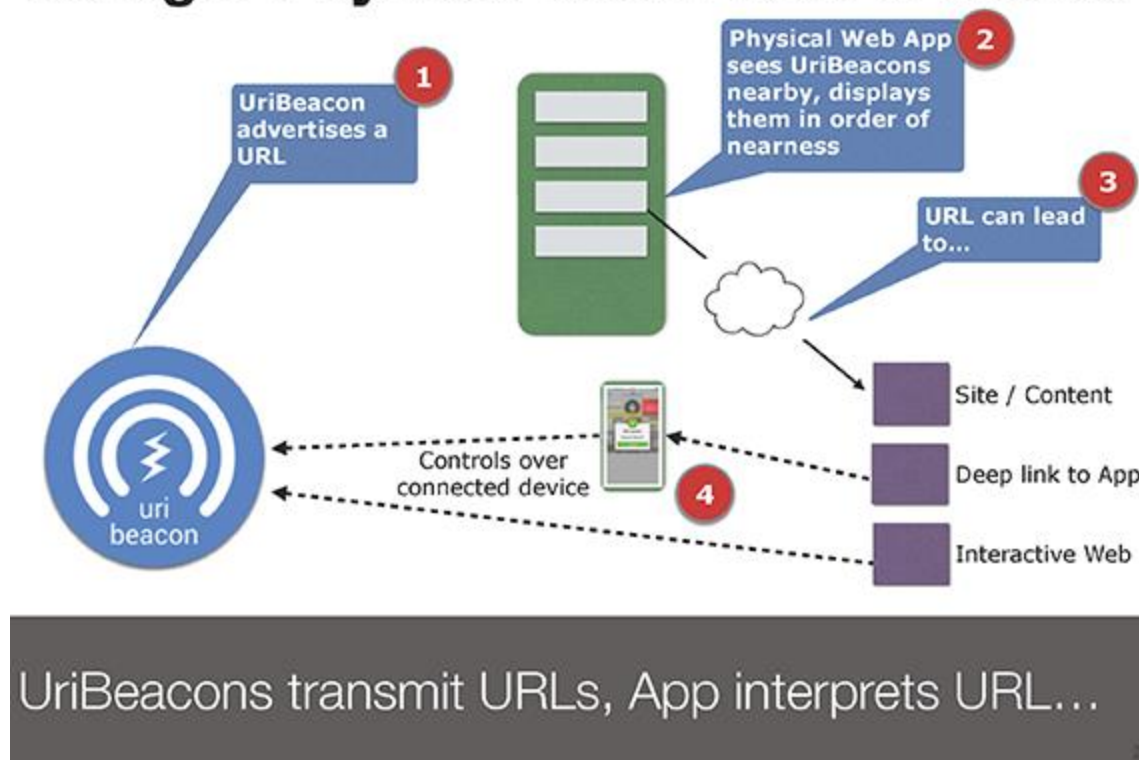


Figure 1: How the Physical Web work [3]

As shown in Figure 1: How the Physical Web work, the Bluetooth Beacon reads a URL, the application using the physical web then reads the near beacon and it then shows them in the order of which they are located and finally, the URL discovered by the

beacon is then lead to the relevant page, website or link to the application or section of the application. [3]

6.2 Bluetooth / RFID

During the last decade, with the launch of short-range wireless communications, such as Bluetooth and Radio Frequency Identification (RFID), a new transmission structure has begun to take off with many devices and services taking benefit of this progress. Based on these wireless technologies, many location-aware applications were created in a variety of fields and professions such as healthcare, logistics and manufacturing. [4]

Wireless solution	Accuracy	Cost	Indoor or outdoor
Bluetooth	2 to 3 metres	Medium	Both
RFID	Under 3 metres	Low	Both

Figure 2: Wireless solutions [4]

Figure 2: Wireless solutions demonstrates wireless solutions for Bluetooth and RFID. There is a significant difference between these solutions. With Bluetooth, this has a higher accuracy than RFID however it could potentially cost more to have a Bluetooth wireless solution. With RFID, its accuracy is under 3 metres however its cost is relatively low to reflect this. Both Bluetooth and RFID can work indoors and outdoors, which would be beneficial for the project as there would be some sensors located on the outside of the building main entrances, so it is good that these can work in outdoor environments. [4]

6.3 Bluetooth Beacons and Beacon Technology

A Bluetooth beacon is a device that is wireless that is based on Bluetooth Low Energy, or BLE for short. It creates a signal that other technology can find. A series of letters and numbers are combined to create a radio signal and a device that has Bluetooth on it can access a beacon once visible to the mobile device itself. [5]

Eli Zimmerman has said that

"universities see a benefit of beacon technology in recruitment" [6]. He then goes onto say that "University IT teams installed 20 Aruba beacons at points along the tour"

and “when prospective students open the self-guided tour applications, it enables location services on their phones. Then, as students pass by the beacons, they receive notifications based on nearby landmarks” [6].

By having this type of self-guided tour, it can assist with students becoming familiar with their new surroundings and it can engage with the community further.



Figure 3: How the Beacons Work [5].

Figure 3: How the Beacons Work . demonstrates how Bluetooth beacons work. Once the signal has reached the mobile device, it pings where the user is currently located, and the device details are sent to the cloud. An example is that if the user is in a university building and the user is walking past a specific room, the beacon located in the area would alert the user that they are currently at this department. [5]

According to Aneta Ciurkot, “Bluetooth provides the infrastructure for the entire beacon ecosystem” that it is “a standard for sending data over short distances, a wireless technology not so dissimilar from Wi-Fi.” [5]

6.4 Geographic Information Systems (GIS)

GIS technology can create telecommunications networks for devices that users use as well as the architecture for internet connections. GIS analyses all data types, once this data has been collated, it unites it with a map and integrates the locational data with all the descriptive data. [7]

GIS collects and allows visualisations of information about specific locations within the Earth. Much information can be demonstrated on a single map, thanks to GIS. [7]

GIS is used to map positions and specific objects and it allows to see what is happening within a specific area. It is also use, more specifically for the following, as shown below in Figure 4: GIS Geography . [7]

Geography	Details
Environmental	This tests the impact the environment has on users.
Physical	This looks at the atmosphere components.
Emergency	It provides live data about the current location to the emergency responders.
Health	It studies health issues (illness) which uses geographic data.
Economic	It looks at the Earths economic events.
Transportation	It looks at the longitudinal communications between users and objects.

Figure 4: GIS Geography [7]

GIS can better communicate visual formats of organisations and its costs are not low, particularly with maintenance fees. It can also record any changes and easy decisions can be made. [7]

GIS has functions on its figures and attribute information about synthesis and analysis. On a map, data would be shown not only in co-ordinate format, but also the topology relation between graphic elements and the function modules of map matching, path query and path lead. [8]

GIS can be used to assist with creating visual plans of information. A good example of this is Google Maps – this is an application for navigation purposes that people use as a mapping solution. Transport problems can be remedied using data obtained by GIS. As GIS can collate topical and environment using a GIS software platform, many organisations can plan few routes for their transport services. [9]

6.5 Global Positioning System (GPS)

GPS is essentially a radio navigation system that discovers the current location user and time in the users' location in real time. The user can be in anywhere in the world, and GPS can still discover their location. [10]

Google Maps uses GPS for its application as it can read the current location of the user in real time, given them navigational instructions and directions to destinations. It also gives live times of public transport such as buses and trains as it can recognise bus stops and train stations. Many health apps track the users' current location while doing exercise workouts. It can track mileage they have exercised as well as collect details about the terrain they have walked. [11]

A useful benefit of GPS is that it can inform the user of which direction to turn to reach their destination. The cost to use GPS is relatively low and its available coverage on Earth is 100%, meaning that it can cover the entire planet and it can direct users to essentially any location they wish to go to. GPS is an advanced technology as it is updated regularly and GPS can be used anywhere in the world as it is controlled by world satellites [12].

GPS comprises of satellites which provides detailed accuracy. There are typically four satellites that can read out the latitude, longitude, and height. Once the GPS receiver collects the data from the satellites, it updates the information in real time which can then analyse the movement direction and speed. [8]

6.6 Indoor positioning

Technologies such as Bluetooth and RFID have been implemented for indoor positioning. Indoor positioning is currently in an early state of implementation because of its difficult environment that makes wireless signals hard to find. [13]

Currently, a technology such as GPS has not been openly created and each indoor positioning technology has its limitations, which hinders its use. Yu, Liu, Chi and Peng say that iBeacons are

"Based on Bluetooth Low Energy devices (also known as BLE) and is initially designed to push notifications to customers when they are close to the beacon." [13]

They then go on to say that "Bluetooth-based positioning technology has been used for active positioning or passive positioning (tracking) in various settings" [13]

6.7 Location Based Services

Essential to location-based services (LBS) are location, mobility, and connectivity, which are all key to computational managerial events. With enhanced access in the contemporary era, LBS have become essentials for businesses and day-to-day living. Its security has become major concerns with implementing location-based applications. [14]

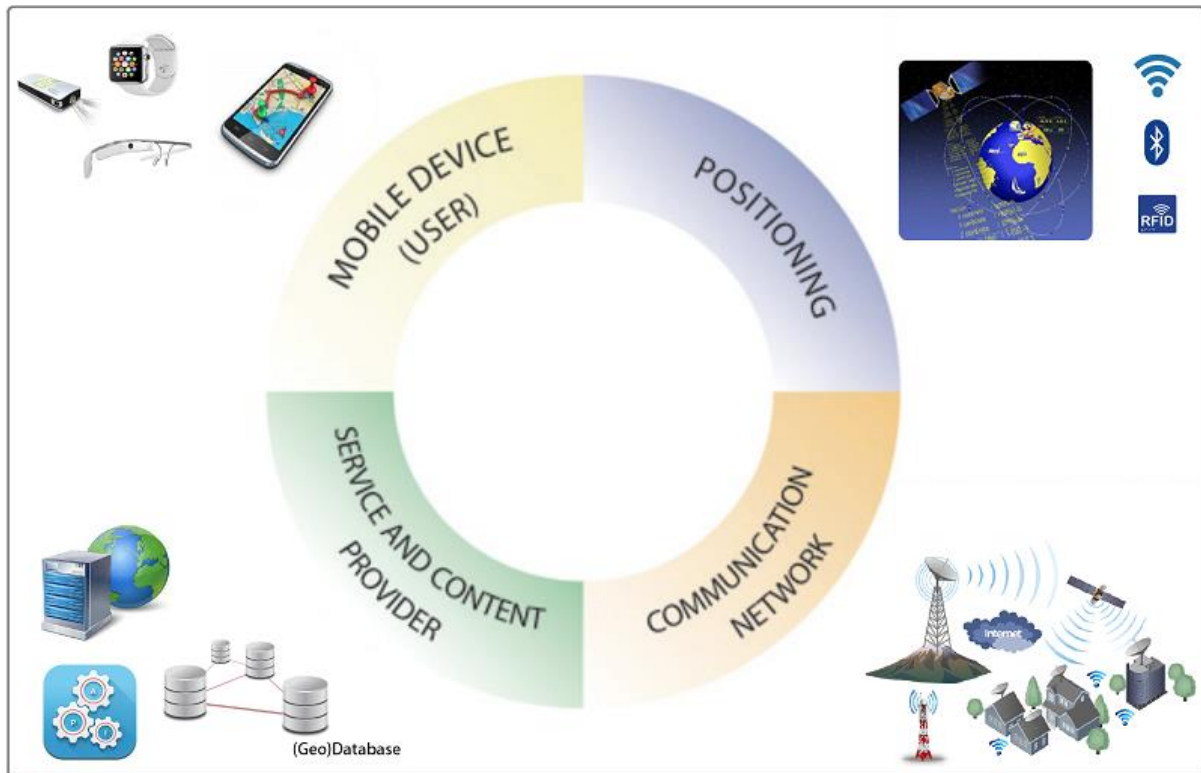


Figure 5: Location Based Services System components [15].

Figure 5: Location Based Services System components . shows the different components for location-based services. A device requests the current location of the user, and these results can be shown either using a map or written instructions and a description of their current location. The positioning component finds out the users' exact location. Whenever there are inaccurate GPS signals, map matching algorithms are implemented. For indoor location-based service applications technologies which are used are Wi-Fi, Bluetooth, and RFID. The communication network, such as Wi-Fi, transfers the request from the user using the mobile device and data to the content provider. The Service and content provider develops the requirements from the users

and then gives the needed data. It regularly accesses sources to retrieve the information to process the service request. [15].

7 Research & Development Methods

7.1 Research Methods

7.1.1 Research Onion

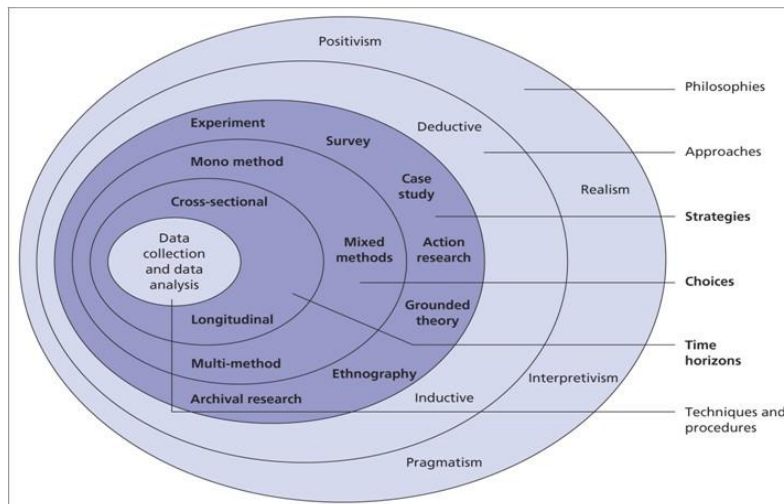


Figure 6: research onion [16]

The research onion was created in 2007, it gives information of the different parts of the onion. The benefit of using this method is that it produces a series of phases of the distinct data collection processes that can be identified. It also shows the steps needed in which a research methodology can be interpreted. [17, 18]

According to the Business Research Methodology, "positivism adheres to the view that only factual knowledge gained through observation is trustworthy". It then goes onto say that "Positivism depends on quantifiable observations that lead to statistical analyses". Positivism is the best approach for this project as, once the application gets fully implemented, users will be asked to test it to ensure that all the functionality works, their actions would be observed – this is to determine that if the user is finding a particular task difficult this can be seen by the developer. By using observation, the developer would see what features the user likes using as well as the features that work particularly well. [19]

The project will contain development, which will be discussed in the following section.

A literature review conducts a detailed analysis of literature which are related to a research area. It helps the reader to find out what the topic of what the research is. By doing a literature review, a clearer understanding of the chosen area of study is

achieved. It is to show recognition of development and to inspire ideas about the aims and objectives of the project. Gaps within the research may be discovered. [20, 21]

7.2 Development Method

7.2.1 Agile

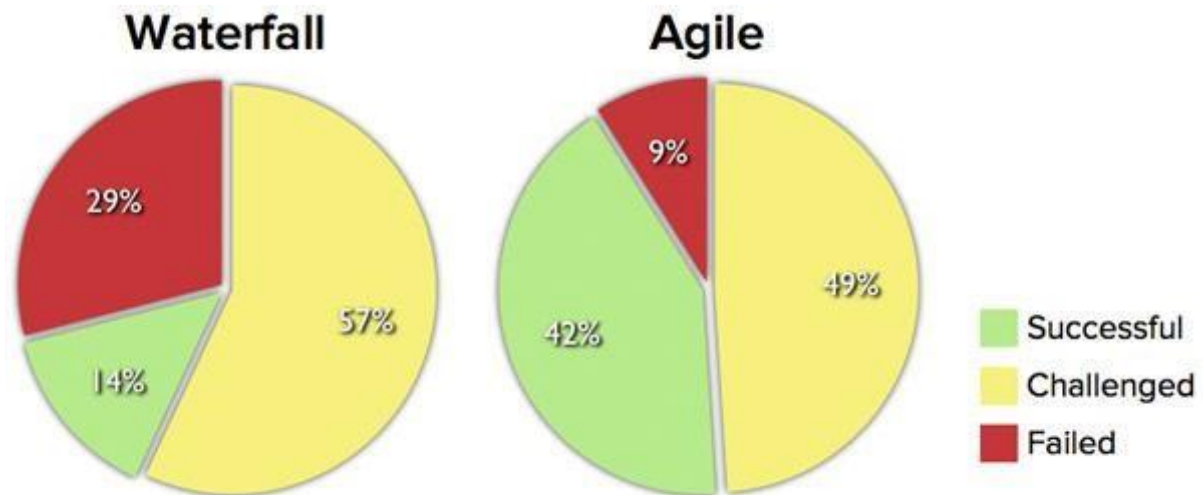


Figure 7: Waterfall vs. Agile [22]

Figure 7: Waterfall vs. Agile demonstrates the two different methodologies of waterfall and agile. Within the waterfall methodology, 29% of projects fail which is 20% higher than the agile methodology however, 57% of projects done using the waterfall methodology has been successful, 8% higher than the agile methodology. Within the agile methodology, 42% of the projects have been challenged and just 14% within the waterfall methodology. This statistic demonstrates to us that, by 28%, there was more project challenged in agile than in waterfall. [22]

Agile assists to create what the client wants as the final prototype, this approach can developer in small bits. The requirements are evaluated constantly as well as the results to see what is working and what is not with the application. The development team can also review the requirements to see whether the objectives set are realistic within the project timeframe. [23]

Agile is good for team working projects and can adapt to changing requirements quickly. According to the digital.ai 14th Annual State of Agile report, 95% of respondents stated that their businesses using the best practices of Agile and that 61% out of the 40,000 respondents had been using this methodology for over three

years [24]. The overall quality of the software implemented is of a higher quality as stakeholders are often engaged with the development team if this approach is used as they can provide the team with feedback to ensure that their requirements are met. Two main advantages of using the agile methodology are adaptability and predictability. Agile teams can adapt to changes moderately quickly and can be done with little disruption to the implementation. If the requirements from the product owner changes, the development team can review and update the implementation consistently. This is all because the agile methodology is adaptable. In most projects, agile teams work in small stages. These are called sprints. These sprints normally last for approximately two weeks and project managers can effectively see the performance of the team, as well as the product, easily. [23, 24, 25]

Developers require training for the agile methodology, to ensure that any software can be implemented effectively. Many developers do not have a full appreciation, or skills, to implement using this methodology. If developers are working on a large project, it is quite hard to use the agile methodology. To make the agile methodology work, some organisations may need to transform some of its practices to make the methodology work, this may require for developers work collaboratively together in partnership. [26]

7.2.2 Waterfall

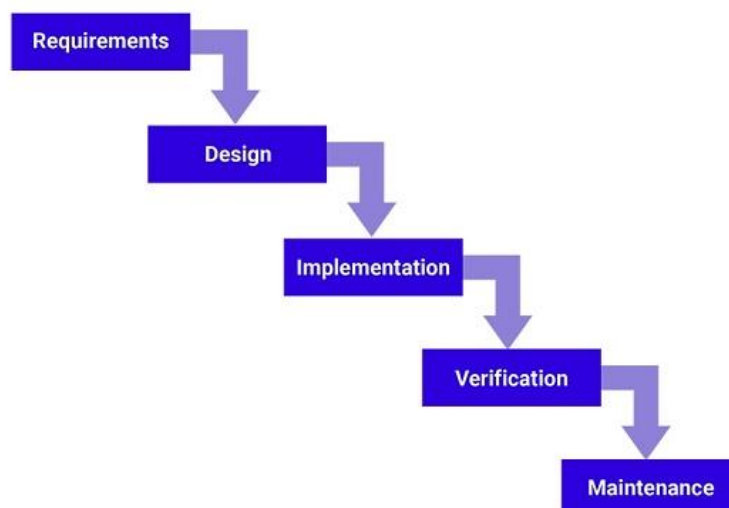


Figure 8: Waterfall Method [27]

The waterfall method was invented and described by Herbert D. Benington in 1956 and it is most used for software development that proceeds in stages. The model starts with requirement analysis and finishes with testing. The disadvantage of using this method is that it is difficult to move back up the waterfall and testing is performed late in the development, by having testing performed late in development, developers could find missing requirements quite late within this stage.

The waterfall methodology is a much-used methodology. It includes 5 stages, which are focussed on set objectives. Each section should be fully completed before moving to the next stage. Each stage is specified flows into the next flowing down stage. [27, 28]

In the requirements stage, tests will be carried out on an existing University tour app to evaluate its features. Investigate potential users to establish what their requirements would be. In the design stage, mind maps would be created to demonstrate what needed to be implemented as well as its purpose. The programming languages for the application will also be included as well as the software required to create the application. In the implementation stage, the software will be coded in a programming environment and the application will be viewed at different stages of development to view what has been done and to see whether anything needs altering. Tests will be carried out to ensure that any issues are discovered straight away, and they can be remedied straight away. Tests will be performed using expected results and comparing to actual results and through user testing and evaluation. In the verification stage, to verify that the application works, users will be asked to test a part of the app, and it would be tested to ensure stability and efficiency. In the maintenance stage, if there are any issues discovered within the verification tests these would be maintained and the application will be re-tested. [28]

The benefit of using this method is that it is straightforward to understand. When clear goals are made, this could be the better methodology to implement for the project. It is effortless to assess the project development. [27, 28]

The disadvantage of using this methodology is that the model is moderately slow due to its tight configuration. If the user is not satisfied with the application in the verify

phase, it could be cause financial constraints to go back to the different stages and re-build the app. [27]

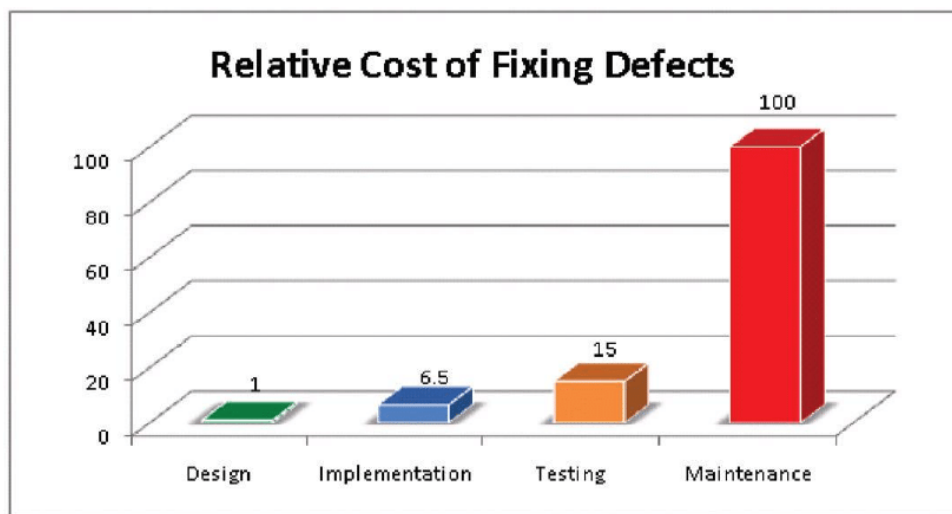


Figure 9: Relative Cost of Fixing Defects [29]

Figure 9: Relative Cost of Fixing Defects demonstrates how costs for errors difference between the start of the project over the end of the project. If any errors with the software are found within the design stage of the project, costs would be minimal with errors found during the implementation stage, it would cost 6.5 time more. At the developer goes through the project, if there were errors discovered within the testing stages of development, it would cost 15 times to fix more than if they were found in the design stage and if errors were found within the maintenance stage, it would cost 100 times more than if they were discovered in the design stage.

Based on the research conducted, it has been decided that the agile methodology will be used for the project because it is more adaptable to change than the other methodologies which is of particular benefit as, due to the aims and objectives not being finalised yet, it would allow for some requirements to be changed. Also, comparing the agile methodology to the waterfall methodology, although the successful rate is 8% lower than waterfall the failed rate is 20% lower than the waterfall methodology signifying that there is more of a chance of the project either being successful or challenge by using agile than waterfall. [22]

7.3 Using Bluetooth Beacons for the UWTSD Self-Guided Tour Application

The UWTSD IQ building is a multi-storey building and will have multiple locations within the building such as computer rooms, classrooms, student services and individual study spaces. Due to the building being tall and large, additional beacons may need to be included within the building, even if it does not link to any location to show on the app. This would ensure that the signal from the Bluetooth Beacon would remain active and could be discovered on a mobile device and this would ensure the app would remain functional.

7.4 Testing

A useful method of testing is by completing a user experience (UX) questionnaire. There will be between 10 and 20 users, and it will be sent via Microsoft Forms. This would measure the attraction of the pages such as whether users like the page they are viewing. Another way of testing is the accuracy of the app, so users are learning the app and how they use it. The effectiveness of the app would also be tested, if the user has any issues with the app, they can discover a solution to it without excessive work than needed and whether the app updates fast to the tasks. Reliability would be measured by the user; they would be asked if they feel they are in power of the app communications. Users could be questioned about its design. [30]

7.5 Data Collection

7.5.1 Pre-Implementation

To collect the requirements of the application, testing would be performed on the Swansea University tour application. Once this testing has been done, a questionnaire would be sent out to determine what is good and bad about an existing self-guided tour app from Swansea University and to see what features could be implemented UWTSD self-guided tour app.

The Student Hwb at UWTSD would be interviewed to collect data on things such as what students ask whilst attending an open day at the university. It is hoped that on open days, a student can go by a particular lab and have a rundown of what is being taught in that room. In the library, the app informs the user of the opening times. Student Services would also be interviewed and be questions on what students with

disabilities what the most difficult thing for theme is presently at the University. For those students who are wheelchair bound, what is lift access like and are they accessible to those students with disabilities.

7.5.2 Post Implementation

Once the application has been fully implemented, further tests would be performed that would make sure that the application works properly and that the objectives have been met. The benefit of testing is that the clients would be satisfied with the end-product as any bugs would be found early in the implementation and could be fixed before being released to clients. [31]

Once the final app has been implemented, questionnaires would be sent out to potential users before and after development to see their responses.

7.6 Are There Existing Apps Similar to the Project?

A similar item of software has been developed by the University previously, however, since then, it has been removed.

Prior to the application being removed from the UWTSD website, there were buttons taking the user the direction they wished to go. These buttons also enabled the user to view a specific area of the UWTSD building. However, there were many problems with the guided tour, the details of the room / area of the building the user would be visiting was limited and there was no audio recording available at all. The app was not designed to be a guided tour whilst the user was within the building as it did not have the ability to read the current location of the user.

The Glynn Vivian Art Gallery in Swansea currently has a multimedia mobile device app as well as a virtual tour available on the gallery website. The virtual tour on the website allows users to navigate around the gallery as if they were there in person and at specific points it has videos, details about the paintings as well as images.

Morrison Hospital has placed beacons for people to travel to a specific location within the hospital. Users get directed through a series of beacons go get to their appointment location.

The Gower Heritage Centre app can read the users exact location and can inform them of which attraction they are nearest to within the centre. It also provides a map, informing the user of their current location, and can navigate around the centre. It also includes a full list of all the places and can be ordered from the nearest to the furthest away attraction.

All the data collected from the testing of the apps will be collated together to see what the good things are and what the bad things are about each of the different applications, they will be analysed and then see which features could be used in the implemented application. The good and bad of both the Glynn Vivian Art Gallery and Gower Heritage Centre apps will be gathered to discover which features work, which ones do not. This would then ultimately decide which features would be implemented on the University self-guided tour app during the development stage of the project.

These applications will be tested because both part of them are moderately similar to the proposed application for UWTSD. The Gower Heritage Centre is likely to be the closest actual application as it uses both GPS and Bluetooth Beacons, which would be used for the UWTSD self-guided tour.

7.7 Risks & Limitations

The limitations involved with this project is that software, such as Microsoft Office and Visual Studio, may be unavailable at times due to updates so that would delay the progress of the project. There could also hardware problems as it could potentially be faulty, meaning that it would either need to be repaired or deemed unusable, this could cause problems with the budget of the project due to costs in repairing or purchasing further items.

7.8 Ethics

An ethics form has been completed for the project. The participants will be informed that only the researcher will have access to their e-mail address (used to send out the questionnaire) as well as comments for testing the application once the project has been finished, based upon the guidelines of the General Data Protection Regulation (GDPR) Policy. The information that is on the application must be correct and in line with university policies.

8 Resources & Planning

8.1 Resources Required

8.1.1 Hardware

- Access to laptops and computers

8.1.2 Software

- Visual Studio
- Microsoft Word
- Microsoft Project
- Microsoft PowerPoint
- Microsoft Visio

8.1.3 Physical Resources

- Bluetooth beacons
- Mobile device
- Laptop / Computer PC
- Library books (where online is not available).

8.1.4 Human Resources

- Testers for the app.
- Project Supervisor.

8.1.5 Other Resources

- Time
- Internet access

8.2 Gantt Chart

A Gantt chart would be used to keep on track with completing tasks and scheduling milestones within the project. Typically, a Gantt chart is used to assist with planning deadlines during projects and how to efficiently distribute resources. It can also help project managers discover specific start and finish date for each individual task as well as and milestones and predecessors to the tasks. [32, 33, 34].



Figure 10: Gantt chart

Figure 10: Gantt chart demonstrates the Gantt chart for the project. Although many of these tasks have already been completed within the research proposal, some of which are subject to change hence why dates shown from May. It would also be the case in the event of changing the project, then new aims and objectives would have to be written. The aims and objectives would be finalised by the 7th of May with further research being conducted for the literature review by the end of May. Both the research and development methodologies would be decided, and written, by the beginning of June with the review of existing applications analysed by the 24th of June. The initial designs of the application, using wireframe diagrams, would be completed by the beginning of July with the questionnaires being sent out by the 4th of July and returned no later than the 16th of July. The results of the pre implementation questionnaires would then be analysed and written within the main project report by the 25th of July. Once these results had been analysed and the features for the application identified, implementation would then commence for twenty days, until the 20th of August. The testing and evaluation would not actually start until the 22nd of August, allowing for an extra two days' work of implementing the app in case of any errors within the app which require to be fixed. The testing would last until the end of August, with the project evaluation taking place until the 3rd of September and reflection until the 7th of September.

9 Expected Results

9.1 Similar App Testing

The expected results from testing similar apps would be that the apps guide you around the venue and give the users some information about where they are currently located within the building. By testing the similar apps, it would show how they utilise the technology, what is good about the app, and what could do with some improvement. This will show what could be implemented into the app within the project for UWTSD, and what features to not include either because of its relevance to the project, or because they are not that usable or accessible.

9.2 Questionnaire

Once the Swansea University self-guided tour has been tested by users, it is expected that there would be features that users would particularly want to be implemented onto the UWTSD self-guided tour app. If there were any features which did not work as well, these would mean that they would not be included within the UWTSD self-guided tour app. The expected results of running the questionnaire is that features for the UWTSD self-guided tour will be determined. The general understanding and knowledge from users about the proposed app would also be collated as they would be asked whether they have used an app like this before. This may affect how they would use the app generally.

9.3 Application / User Testing with a Questionnaire

Participants would be invited to test all the features of the web app and evaluate their findings. They would also be asked to rate the features of the app. By having tests done once the implementation had been completed, it would be determined how reliable the app is, how many bugs there were, if any, and how many fixes would be required. Once the tests had been completed, the user would receive a questionnaire to state their opinions on what was good about the app, would be improved about it, and is there any features they wanted to see or removed from the app.

9.4 Application

The expected result of the final application is that it will interact with Bluetooth Beacons to read where the user is in the building and provide them with locational information.

10 Evaluation

The report sets out the proposal for a project to implement a university tour app using Bluetooth and GIS. The use of GIS and Bluetooth for providing location information has been researched as well as two similar apps to see how they work. It was promising to see that at least 1 of the applications tested is similar to what this project research proposal outlines, which is promising as this demonstrates that the app proposed can be done.

Although the proposed research has got its benefits, it does carry some limitations and weaknesses with it also. A key limitation to the proposed research that, due to ever-changing geographical information it would be essential that the proposed app would be always maintained, to ensure locational accuracy. The technology is also rapidly changing and is always being updated, this means that older technology is quickly becoming incompatible. There may become a time where some Bluetooth beacons could become incompatible and un-supported by some mobile devices, signifying that new technology would have to go in its place which could cause some financial constraints as these may not be taken into consideration. The same would apply if a Bluetooth beacon became unusable due to being either broken or damaged, this would be unexpected which may cause some issues with the project budget. The University is closed at certain times of the year for either closure days or bank holidays, as the beacons would be based within the IQ building at the University access to the building is imperative so ensure that implementation and testing is not affected by these closure days.

Due to there being a deadline for the project, there is a chance that the app would not be fully implemented. Primary data may be limited due to time constraints.

In terms of technical constraints, either due to updates being performed or the technology required not being available, software could become an important factor as this would be required to create the final prototype as well as test it and if the software is not available, this could set the project back. The same would be applied if the developer's laptop is unavailable due to being repaired or updating, as all the files would be stored locally on the laptop if it became unavailable this could set the

project back by, potentially, a few weeks. The GDPR could also be a technical constraint as consent

For the early developmental stage of the research area, some wireframe diagrams would be created so that an initial design can be created to give an insight in to what the final prototype will hopefully look like, create a potential interface, and gives the app its overall structure. This would take place prior to implementation so any changes to the overall design can be made during this stage of initial development.

The aim of the project is to build a university tour web application for the UWTSD IQ building which utilises GIS and Bluetooth to provide the user with locational information. By the end of the project, it is hoped that a working prototype will be create within the project deadline.

To conclude, a self-guided tour app for new students at UWTSD would assist with self-orientation with the campus and ensure that their transition into the university is seamless.

11 Reference List

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