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SeniorsCycle

Design and implementation of a cycling activity tracking, sharing and analysis system for senior citizens

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August 2015

MSc Computer Science – Newcastle University

[Word Count: 17,472]

I. Declaration

I certify that all material in this Assignment which is not my own work has been identified and that no material is included which has been submitted for any other award or qualification.

I declare that this assignment is my own work and that I have correctly acknowledged the work of others. This assignment is in accordance with University and School guidance on good academic conduct (and how to avoid plagiarism and other assessment irregularities). University guidance is available at

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Signed:

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Date: 27/8/2015

II. Abstract

Cycling is a low-impact exercise that has many environmental, physical and mental health benefits and can be enjoyed by people of all ages. It is an inexpensive way to exercise and contributes significantly to building stamina, strength and muscle tone, improving cardio-vascular fitness and reducing stress. However, the vast majority of senior adults tend to abstain from this beneficial activity. The aim of this project is to encourage senior citizens to cycle by allowing them to easily track and share their cycling activity with fellow cyclists. The project includes an Android application that works in tandem with a responsive website. The most important advantage of the system is the simple user interface and a wireless sensor called “Beacon” that automatically starts and terminates the recording of a cycling route, minimizing the need for frequent user interaction. Finally, in order to ensure the functionality and evaluate the usability of the system a workshop was organized and the majority of the participants were satisfied by the features, the design and the effectiveness of the system.

III. Acknowledgements

I would like to thank my project supervisor Dr. Vines, Dr. Clarke and my brother, Christos Papaterpos for their valuable guidance, help and support during the development of this project.

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1. Introduction

The aim of this project is to make cycling more appealing and engaging for senior citizens, by allowing them to easily track and share their cycling activity with fellow cyclists. Cycling is an important method of transport in parts of Northern Europe even for senior people and its benefits for both the health of the cyclists and the environment are widely known. However, only 4.8% of the total number of cyclists in the United Kingdom is older than 40 years old, (cycle BOOM, n.d.) despite cycling being "the third most popular recreational activity in the country" (Nhs.uk, 2014).

1.1 Project Objectives

The aim of the project is to bring together and develop a composite information system. The requirement of the system is that it comprises an effective, very simple to use smartphone application that helps its users track, view and share their cycling activity and a central web site which enables easy sharing and viewing of tracked cycling activity. Within this context, the project's aim is broken into the following set of objects:

- Development of an Android application that tracks user cycling activity, records related data on the mobile device and allows the user to share a route online.
- Development of a responsive web site which allows users of the application to view information on cycling activity shared by other users. The web site is currently hosted at www.seniorscycle.co.uk and the application can be downloaded directly from the server.
- Synchronization between the local, on-device, route information with the respective information maintained on the web site.
- Design of a simple and minimal user interface by following Mobile User Interface Design, responsive Web Design principles as well as a best practice of inclusive design for seniors.
- Testing the usability of the system, including a small trial with a small number of senior cyclists.

From a personal improvement perspective, the main objectives were to: improve the author's Java programming skills; acquire experience with Android Studio; explore the use and the capabilities of Estimote Beacons[1]. Additional objectives included gaining experience in the design, development and testing with real user involvement of a complex, composite information system that combines the functionality of a mobile application with a web site through implementation and exploitation of web services.

[1] http://estimote.com

1.2 Project Description

As mentioned above, the project involves the development of a mobile application addressed to senior people that works in tandem with a web site. It records data related to cycling activity, such as routes, average speed and time and takes into consideration usability and accessibility issues for this target group. The application is enabled with the use of an Estimote Beacon, a wireless sensor with an integrated processor, memory, motion sensors, and thermometer that can be attached to objects and broadcast radio signals via a Bluetooth module. These signals are received and interpreted by an Android smartphone. The data is stored locally and whenever an Internet connection is available, the users have the choice to share the selected route data online. The application posts the related data to the web site, through a custom web service and fellow cyclists can enter their friend's username/nickname to view the routes that have been shared online.

1.3 Initial areas of research

The project follows an "Agile" process development (Cohen et al., 2004). Project development included regular meetings with the supervisor and the rest of the team that assisted with some technical issues. The main purpose of each meeting was the selection of the features to be implemented. Each meeting focused on continuous design improvement and refactoring, including regression testing, to make sure existing code had not been broken by the new additions. The initial step of the project development included a detailed review and critical evaluation of background material relevant to the project. This involved a review of existing applications, products and digital services in this research area, as well as relevant literature that can be a valuable asset towards the completion of the system. Issues such as privacy and usability required documentation that can be found in the next chapter.

Furthermore, it was considered essential to:

- Set milestones and create a Gantt diagram.
- Conduct literature review, focusing on the following issues:
    - Multi-Layered Interfaces to improve older adults' initial learnability of mobile applications.
    - Mobile sensing system for cyclist experience mapping.
    - Design requirements for technologies that encourage physical activity.
    - Mobile UI Design principles.
    - Agile software development for mobile applications.
    - Scenario based design for measuring user experience.

1.4 Expected outcomes

The direct expected outcome of the project would be a composite information system that comprises an Android application that exploits features of the smartphone (e.g. GPS) and utilizes the services of an Estimote Beacon and a web site that hosts

appropriate web services which can receive data on users' cycling activity from the user's smartphone. This project was expected to produce a clearer understanding of possible motivations to senior citizens in order to maximize their cycling activity. The system aims to record data related to their cycling activity, such as routes, speed, stops and will take into consideration several usability and accessibility issues.

1.5 Dissertation Outline

In the next chapters the following topics are discussed:

- Background technical material: A detailed review of the background material that consists of an extensive literature review that focuses on the relationship of older adults with mobile devices and digital – material communication practices, usability principles, the development of privacy guidelines for social location disclosure applications and services and a few similar commercial applications to "SeniorsCycle».
- Development Process: A detailed description of all the appropriate steps of the development process and sketches of a real – life scenario.
- Results & Evaluation: Description of the workshop that was organized in order to evaluate the usability of the system, comments, results, analysis of the questionnaires and several charts; correlation of work done with presented literature review and System Testing
- Conclusions: Positive and negative aspects of the project, learning outcomes, future work and improved updated versions.
- References: An organized reference list.
- Appendices: Various documents relevant to the project, such as meeting reports, workshop posters, additional anonymised information from participants, questionnaire example.

2. Background Technical Material

The main purpose of this chapter is to contextualize the current study, explain its relevance to the project and allow the reader to identify basic similarities and differences between "SeniorsCycle" and other products. The background resources focus on the following subjects:

- How Older Adults Learn to Use Mobile Devices.
- Usability principles.
- Digital and material social communications for older adults.
- Communication practices of older adults in the digital age.
- Development of privacy guidelines for social location disclosure applications and services.
- Similar commercial applications.

2.1 Adults and mobile devices

Undoubtedly, one of the most important factors of the system's functionality is related to its learnability from the perspective of its users. Older adults belong to a target group that adjusts slowly to major technological changes, especially nowadays that mobile computing devices, such as smartphones tend to substitute laptops and personal computers, since mobile devices are increasingly pervasive and computationally powerful.

Smartphone applications can provide standard tools to older adults, as well as assistive technology, that (Leung et al., 2012) "can help older adults remain more independent and maintain their quality of life as they experience declines in perceptual, motor, and cognitive abilities due to natural aging". For instance, "Glooko" (Glooko | Type 1 & 2 Diabetes Remote Monitoring Software | Population Management, n.d.) allows the user to upload glucose readings directly from his meter, "Symple" (Symple Symptom Journal and Health Diary, n.d.) keeps daily notes and photos, and records medications, exercise, and other factors related to shoulder pain or headaches and "Drugs.com" (Drugs.com, n.d.) provides a personalized drug list to keep track of medications through an extensive drug database and identifies unknown pills by entering their imprint, shape, or color.

According to a survey conducted on behalf of Ofcom (2009), adults in their sixties tend to learn more easily compared to those aged 70 and over. Another important fact is that male adults aged 60 and over are more interested in experimenting with new technologies rather than females. "The mobile phone functions of most interest to older people are: locking the phone (69% vs. 85% of all adults), and sending a text message (58% vs. 89% of all adults) (…), while 66% of older adults are interested and

confident in using any of the services, compared to 88% for all adults. Two of the five mobile phone functions register higher levels of older people saying they are interested in carrying these out but lack confidence, compared to the general adult populations: sending a text message (13% vs. 8%) and locking the phone (13% vs. 8%). These two functions are the most likely to be of interest to older people. For two further functions – taking photos and sending them to people using the phone, and sending a text message to more than one person at a time - similar percentages of all adult users and of those aged 60 and over are interested in the function but not confident in its use".

Since 2009, the year the above survey was conducted, a large number of features have been added to mobile phones and consequently they have become even more complex for older adults. For example, SMS texts have been substituted by instant messaging and Voice over IP (VoIP) applications, such as Viber, WhatsApp and Skype due to low cost and characteristics, such as group chat, video calls, emoticons and file exchange. Smartphone users seem to prefer social media platforms like Facebook, Twitter and Instagram to communicate with each other. The question is how quickly could an older adult familiarize and make use of these new capabilities.

According to a newer study by Ofcom (2014), "adults aged 60 and over are considerably less likely than adults as a whole to say that they regularly use newer media such as a mobile phone (48% vs. 77%)". A possible cause of this deference could be the lack of access to a mobile phone since only three in five older adults use a mobile phone (60%), while over four in five of all adults (85%) use a mobile phone. Similarly, "80% of older mobile phone users say they regularly use a mobile phone, compared to 91% of all adult mobile phone users". In addition, older adults are more likely not to have confidence in the following functions: "transferring photos from a digital camera or mobile phone to a computer (25% vs. 18%) and finding out about local services, such as council, hospitals, leisure facilities etc (17% vs. 10%). It is mostly the case that older adults are less interested in the functions rather than less confident. However, older adults are more likely to say they lack confidence in two of the nine functions: transferring photos from a digital camera or mobile phone to a computer (25% vs. 18%) and finding out about local services, such as council, hospitals, leisure facilities etc (17% vs. 10%)".

2.2 Usability of the system

Based on the above facts it is important that the system should take into consideration several usability and accessibility principles. As stated by Alan Dix, "learnability concerns the features of the interactive system that allow novice users to understand how to use it initially and then how to attain a maximal level of performance" (Dix, 2004). The term learnability consists of:

- Predictability (helps users to predict future actions).
- Synthesizability (helps users to assess effects of past action).

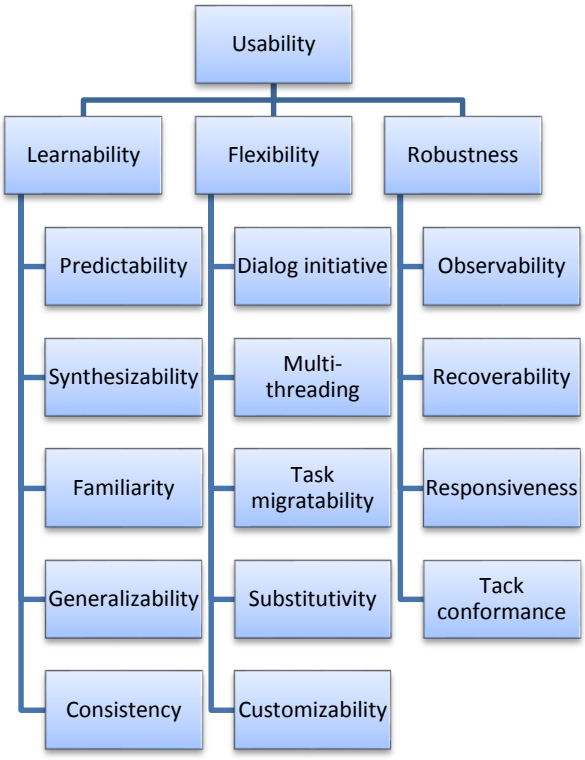
- Familiarity (helps users to apply past knowledge).
- Generalizability (helps users to extend their knowledge).
- Consistency (similar behavior in similar occasions).

On the other hand, "flexibility refers to the multiplicity of ways in which the end – user and the system exchange information" (Dix, 2004). Flexibility is a combination of:

- Dialog initiative (who controls the dialogue flow).
- Multi – threading (support simultaneous tasks).
- Task migratability (how easily functions can be moved between user and system).
- Substitutivity (allows equivalent values of input and output to be substituted for each other).
- Customizability (interface can be changed to satisfy users' needs).

The principles that affect robustness are:

- Observability (helps users evaluate the internal state of the system).
- Recoverability (helps users take corrective action).
- Responsiveness (how users perceive the rate of communication).
- Task conformance (the degree to which the system support users' tasks).



Picture 1: Principles to support usability

Most of the above principles are implemented through the project in order to produce a more usable experience. More details can be found in § 4.3.

2.3 Digital and material social communications for older adults

Social media is a powerful tool that can connect family and friends across long distances as well as link people with similar interests. Social media has been widely adopted by younger adults, but older adults have been less likely to use such applications.

It has been documented in literature that the strength of social support networks in late life is closely related to health and well-being (Lubben et al., 2003). Greater use of the Internet as a communication tool has been associated with lower levels of late life social loneliness (Sum et al., 2008). Online activity also allows seniors to regain control over their personal and social life, which may have become compromised due to age-related changes, by connecting with others and seeking information online (McMellon et al., 2002). The number of older adults in developed countries is today much larger than in the past, and this trend seems that will continue for years to come. The percentage of people over 65 years old will exceed 20% of the total population (Vincent and Velkoff, n.d).

Even though older adults seem to be the ones who would benefit the most from increased use of social media and technologies, they seem reluctant to adopt such technologies in their everyday life. Older adults are less likely to use social media, such as Facebook, as they grow older in life. For example, a study (Bell et al., n.d) conducted in the United States identified that the average age of older adults who are users of Facebook is 66,5 years old, whereas the average age of older adults who are not Facebook users is 75,3 years old.

In general, people in old age interact with others far less than those in youth. However, this is only one of the reasons for their low use of online social media services.

2.4 Technological divide

A usually cited obstacle for the adoption of online social media by older adults is the technological divide between elder and younger generations. Naturally, being able to use technology is an enabling factor for participating in online social networks. Within the results of the survey reported in (Bell et al., n.d), it is demonstrated that older adults who felt more able to use new technology were more likely to be Facebook users than those who felt less able. Although older adults were less likely to use technology in general than younger adults, individuals who felt more confident in their ability to use computers were more likely to use technology than those who felt less confident.

However, in spite of its significance in other technological aspects of everyday life, it seems that lack of technology skills is only one factor that discourages older adults to use social media.

2.5 Devices for Social Interaction

In order to identify obstacles and opportunities in adapting social media for communication, one needs to study how older adults employ more conventional communication devices. Findings from a recent study (Hope, et al., 2014) suggest that older adults prefer to use telephones, emails and written letters for communicating with others. Telephone conversations exhibit a dynamic nature and their use better approximates a real conversation. Email is valued mostly for utilitarian purposes and letter writing is an established social practice for the better educated older adults. Letter writing allows older adults to communicate with strong ties and reconnect with ties that have become weak while affording varying degrees of formality depending on the content, tone, and even the choice of paper used. Writing letters and e-mails enables not only immediate reflection on communication but also provides self-satisfaction to older adults who revisit correspondence at a later date.

2.6 Communication patterns

According to the results of a study reported (Karimi and Neustaedter, 2012), a set of communication patterns can be identified in the ways that older adults socialize with their friends and relatives. These patterns vary with regard to their classification in a communication continuum that ranges from social isolation to continuous high connectivity. Social interaction is a fundamental mean for staying in contact with family members and friends. When family members or friends do not live close enough for this interaction to take place face to face, modern day technologies, such as email, video chat or social networking sites can be used instead. However the use of such technologies is challenging for older adults. The communication patterns identified are:

- Basic technology usage: Many older adults are comfortable using telephones for communication and a small portion of them, mobile phones (feature phones). Usually these people are not socially isolated, since they make extra efforts to communicate with others.
- Constant connectivity: Several older adults utilize more complex technological communication means, such as a smartphone, social media tools like Facebook, or video chat systems like Skype to communicate with others. For them, a high degree of connectivity is a way to avoid social isolation.
- Spontaneity and autonomy: Many individuals do not like to be tied down to commitments to meet with people to talk in person or on the phone and instead preferred to take advantage of their time. They still keep in contact with their family and friends, but there is a strong preference to be unstructured in doing so.
- Isolation and lack of reciprocity: Some individuals experience challenges in establishing reciprocal two way communication using technological means. In some cases, this entails complete isolation from nearly all family members.

The diverse communication patterns exhibited by older adults in their communication with friends and family suggest a range of design needs for communication technologies for older adults.

2.7 Motivational factors for using social media

On the other hand, quite common and useful is the utilitarian perception of the Internet and social media. Older adults use online services to discover information and content that they deem useful for them and for the social circles around them. In fact, some older adults with ease of access to computers and the Internet create printed copies of pages and posts found online (even Facebook posts) and distribute these hard copies to members of their "real-life" social groups who cannot access such information due to their limited technological abilities.

Of course, the main reason for older adults to use online social media is their ability to communicate with their children and grandchildren. In the survey results reported in (Bell et al., n.d), Facebook friends of older adults are members of their family or real life friends (at rates that exceed 80% of Facebook users), whereas less than half of them are friends with people with whom they have less tight social relationships (e.g. colleagues, acquaintances). A small minority of older adults who are Facebook users interact socially with people that they have never met.

Another aspect of online communication that they seem to value is the asynchronous mode of online communication; sending an email to 5 recipients spares them the time to make 5 lengthy phone calls.

2.8 Design considerations for a system that fosters online sharing

With regard to design considerations when designing systems that foster online information sharing within communities of older adults, the study in (Hope, et al., 2014) makes the following proposals:

- Social media for older adults should foster strong tie relationships. Existing social media is considered lightweight by many older adults, and this stands in contrast to their desire to engage in thoughtful communication that often requires an investment of time and attention to composition.
- Older adults often want to connect with younger family members, who are active on mainstream social media sites.
- Older adults find value in doing research for members of their social network and may play an important role in the social question and answer behavior of younger people.
- Older adults are more interested in one-on-one communication than mass communication to a broader audience, but certain situations are exceptions to this.

- Older adults want news from venerated sources and do not feel that political and religious views should be shared on social media.
- For older adults, material social communications afford expression of thoughtfulness and concern, and the medium and meaning of social media are intertwined.

2.9 Concerns for using online social media

Online social media use seems to be disregarded by the majority of older adults. Even the ones who log on to Facebook are not inclined to post online; they prefer to use Facebook or Twitter to follow posts made by others (e.g. family members posting photos of their grandchildren or tweets posted by famous persons).

Their main concerns with using social media are:

- Social media are tools for younger people. Older adults don't feel confident in joining a community that targets younger generations. Furthermore, even though there are social media designed for the elderly, older adults seem to be indifferent to these options.
- Of social media in a way that creates value and exhibits reciprocity is time consuming for older adults. Especially, since they find the content to be unimportant and trivial.
- Social media is a source of continuous communications, which is something that many older adults prefer to avoid.
- Fear for threats to privacy, not just for the information that they would post but also for information published by younger members of their families online.

2.10 Privacy

As mentioned in the previous paragraph, threats to privacy are one of the most important concerns for older adults using online social media. This concern is evident in many classes of users of today's digital technology and developers take into serious consideration several issues in order to protect users' data and allow them to select which of it shall be visible in public.

According to experiments conducted for the design process of "Reno", a location-enhanced, mobile coordination tool and person finder, "participants shared different levels of detail about where they were based on who was asking, what the participant was doing, and/or why they thought the requester wanted to know". Another interesting finding of the same research indicates that some of the participants shared details whenever they were out of state for work or vacation. "This meant that our prototype would need to support various levels of location granularity".

One of the aspects of privacy that plays a significant role is not only what exactly users share online but who do they wish to share to with. It is quite interesting to examine if communication of location among individuals within their social networks

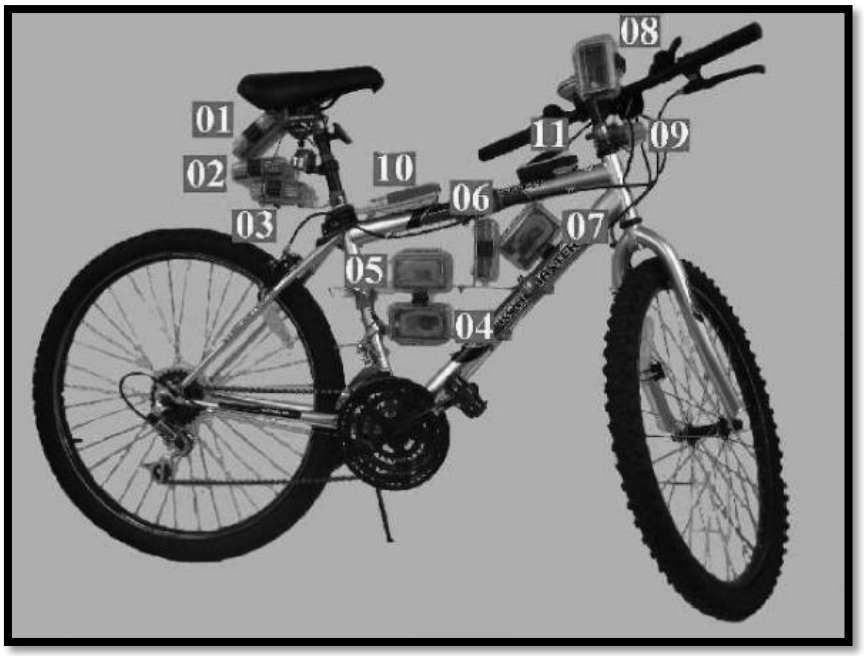
is usually shared between close friends or family. The same experiment proved for example that, "many participants were very bothered by the hypothetical requests that came from their manager and even found requests from some of their (not too close) friends or family members to be awkward, particularly when requests came from people who lived out of town". One of the experiment's conclusion is that the majority of the participants suggested a location disclosure application that would provide relevant information to their location in order to coordinate with others in circumstances such as meetings and appointments, as well the typical "okayness checking" when the user wishes to inform someone that has reached a location safe or in time.

2.11 Similar Applications

2.11.1 BikeNet

BikeNet (Eisenman et al., 2009) is a mobile sensing system for mapping the cyclist experience designed to gather quantitative data about the cyclist's rides, such as current speed, average speed, distance traveled, calories burned, together with advanced metrics, such as path incline, heart rate, galvanic skin response and environmental data for example pollution levels and noise levels). The system uses a dual-mode operation for data collection with wireless access points in a delay-tolerant fashion by default and establishes real – time communication with the user's mobile phone. Similarly to "SeniorsCycle", BikeNet provides a Web-based portal that can be accessed by every user and allows them to view various relevant data and share for example their favorite cycling routes within cycling interest groups, and data of more general interest, such as pollution data with the broader community.

Undoubtedly BikeNet is considered as a reliable fully functional system that is associated with a variety of useful data that also allows the user to select what he / she would like to share online with other users. The disadvantages of BikeNet involve the complexity of the system architecture, the amount of sensors and hardware that most probably eliminate the chance of commercial use and the fact that the user is obliged to use a Nokia N80 mobile phone and not a phone of his preference.



Picture 2: Physical implementation of the BikeNet system

2.11.2 Endomondo

Endomondo is a multilingual social fitness mobile application for multiple sports, like running, cycling, walking, mountain biking, kayaking, skiing etc. and is compatible with Android, iOS and Windows phones. It was created by Endomondo LLC and was launched in 2007. The application (Endomondo.com, n.d.) uses a Real-Time GPS Tracking Live Map and allows the user to track a workout, review workout history, compete against a friend or set a distance goal and get audio feedback on performance.

In addition, the user can customize the workout screen with data such as distance, duration, pace, heart rate, calories etc. and is able to connect the app with a heart rate monitor. Probably the biggest advantage of the application is the social and the motivational aspect, since the user is able to add pictures and write a status message related to the workouts, follow friends, set up a challenge and compete against friends or other members of the community. Similarly to «SeniorsCycle», the user can discover new routes and share them online.

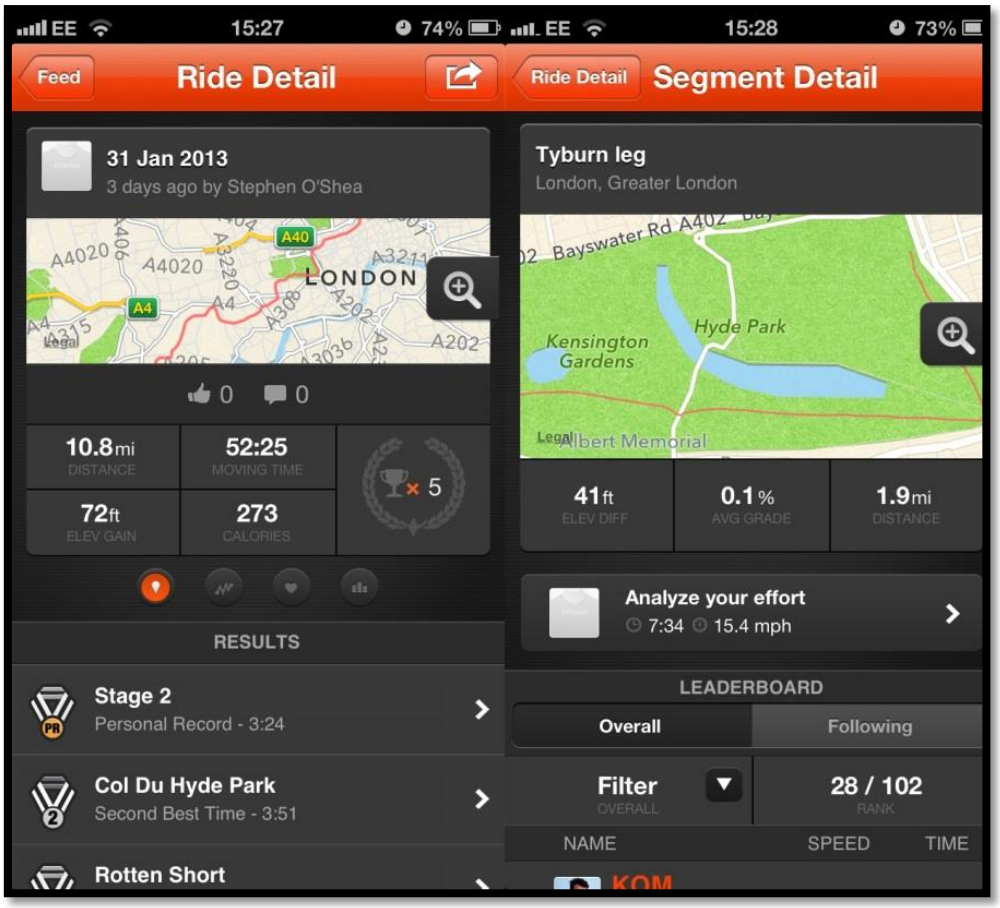
Picture 3: Running with Endomondo

Picture 4:Cycling interface of Endomondo

2.11.3 Strava

Strava is a mobile application for Android, iOS and Windows phones used to track athletic activity via GPS. The paid version of the application (Strava.com, n.d.) provides access to additional detailed data and is used mainly by professional athletes. Strava currently focuses on the needs of avid runners and cyclists by letting the track their rides and runs and just like Endomondo, aims at providing motivation and camaraderie even for people that exercise alone.

The alteration between Strava and Endomondo includes a number of characteristics such as the ability to search the database for routes and athletes, a ranking of times on specific routes, and the top athletes for those routes. Comments are allowed in routes that are not marked as private, while periodic challenges are also enabled and the winners receive a badge displayed on their profile pages.



Picture 5: Strava interface

3. System description

3.1 Introduction

As mentioned in the first chapter and in the project proposal, the aim of the project is to offer Information and Communication Technology (ICT) support to senior cyclists, in an attempt to make cycling more appealing and engaging to individuals belonging in the abovementioned target group.

The present chapter of the dissertation includes a detailed presentation of the system that was designed and implemented through the attempt to meet the objectives above. In other words, this particular chapter describes "what was done" within the scope of the project. Furthermore, the chapter documents the reasons behind various design and implementation decisions, providing thus insight on "why things were done the way they are being herein presented".

The first part of the chapter describes the methodology that was adopted in order to meet the objectives set (3.2. Design and implementation methodology). In this paragraph an attempt is made to describe the approach taken, justify its choice and document how the approach chosen was followed. At the same time, in this paragraph, software engineering aspects of the project are covered.

The second part of the chapter (§3.3 - §3.7) provides a high level description of the outcome of the project, from various software engineering aspects, in terms of:

- Functional requirements.
- Design decisions and overall system architecture.
- High level functional description of the software components that were developed.
- Implementation concerns, decisions and details of the software components that were implemented.
- Issues and limitation of the technical result of the project as well as potential for future work on improvement and expansion of the system.

In every step and at every level the approach taken is discussed; emphasis is placed both on what decisions were taken and why and at the same time, how these decisions were actually implemented.

3.2 Design & implementation methodology

3.2.1 SW engineering approach

As defined in the proposal document, the implementation of the project followed an "Agile" development process. The "Agile" process chosen was organized in distinct cycles, consecutively. Within each cycle, four main software engineering activities were repeatedly carried out as a set of consecutive steps:

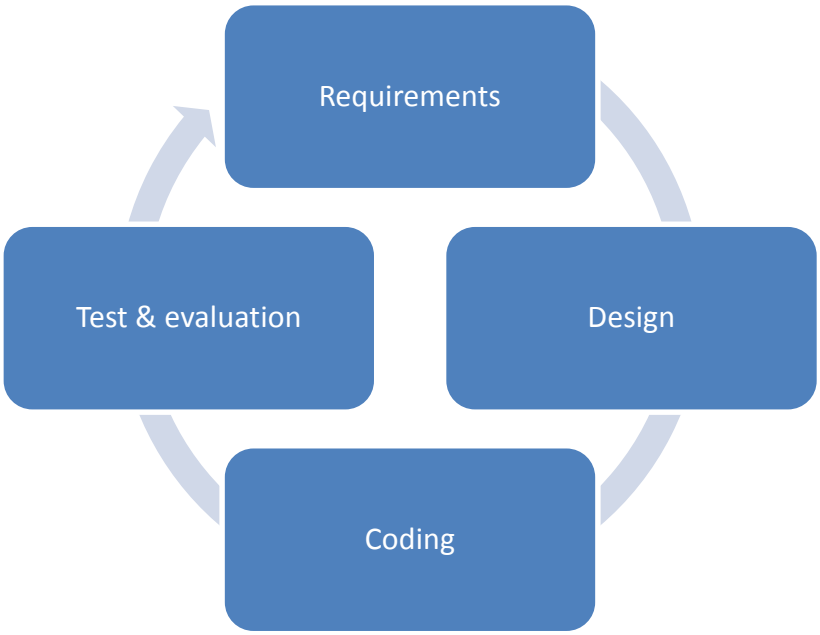
Step one - Requirements: The first step of each cycle focuses on the identification, refinement and finalization of functional and technical requirements. Iterations of this step led to the final definition of the system's functional requirements, which are laid out, in the form of use cases, in paragraph §3.3

Step two - Design: The second step in each cycle is about taking system design decisions for the implementation of the required functional behavior. In each cycle, decisions that were previously taken were altered, in order to allow for implementation of new requirements that were deemed important in Step one and for removal of components that were designed for requirements that were dropped in Step one of that particular cycle.

Step three - Coding: The third step in each cycle includes the implementation of various software components that comprise the system's architecture.

Step four – Testing & Evaluation: The final step in each cycle includes testing and evaluation of what has been implemented within the cycle. Test and evaluation results drive the requirements, design and implementation steps of the following cycle. The final step of the final cycle completes the project with the complete documentation of the effort made. Part of this documentation is this text.

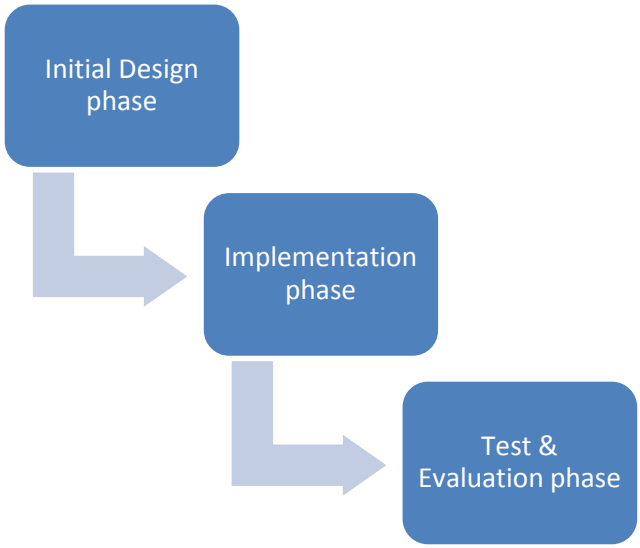
The steps described above, by contrast to the development cycles or phases, should not be seen as distinct time periods within the cycle. They should be considered more as groups of activities with a common nature. The above iterative process is demonstrated in the respective diagram.



Picture 6: The iterative process of the development

For the implementation of the project three distinct cycles were organized and followed, each comprising the basic 4 steps mentioned above. The three cycles or

phases are organized sequentially in a waterfall like fashion, as demonstrated by the diagram below.



Picture 7: The three cycles - phases

In the following paragraphs, a more detailed description is given of the specific steps taken within each cycle.

3.2.1.1 Cycle 1: Initial design phase

The aim of this phase was to specify precisely the requirements and design of the system to be implemented. The phase started with the drafting of the project's proposal and ended with a concrete first set of requirements and design specifications. The initial design phase included the following steps:

Step 1 – Requirements: The functional and technical requirements of the project were discussed. Initially, the scope of the project was focused on home orientation and exercise of elderly people. Furthermore, it was originally considered that users would control the definition of their routes by an appropriate user interface of the mobile application. However, during the requirements step of the first cycle, it was finally decided that the application revolves strictly around cycling, that identification of routes would be done through the use of Bluetooth low emission Beacons and that route data would be published on a web site.

Step 2 – Design: The architectural outline of the planned system was drawn. Originally the system was supposed to include just a simple mobile application. However, it was finally decided that the system would also include a public web site. The mechanism for sharing information from the mobile phone to the web site was also decided upon. A first version of the user interface of the mobile application was

sketched through the production of mockups that were drawn using the Balsamiq Mockups tool. Design decisions also included use of the mobile device's accelerometer, utilization of GPS, low emission Bluetooth Beacons, etc.

Step 3 – Coding; Development environment for the project was setup. This included setting up correct and up to date versions of the JDK and the Android SDK.

Naturally, without the final definition of neither requirements, nor design, it was not possible to start the actual coding for the project. However, serious coding attempts were made, with the intent of familiarization with specific, non-trivial, programming tasks, such as discovering Beacons in the vicinity of the mobile device and retrieving data from the Beacons, reading location data from the GPS of the mobile device, designing an initial database schema and performing test connections and queries to the database, etc.

Step 4 – Test & Evaluation: The goal of this step was to validate the design decisions taken in step 2 and to test the results of coding that was done within step 3.

3.2.1.2 Cycle 2: Implementation phase

Step 1 – Requirements: The aim of this step was to refine the system requirements, based on discussions with the team overseeing the project as well as results from the coding and testing steps performed in the first cycle. Examples of changes in the initial requirements include the decision to rely solely on Beacon proximity in order to identify start and end of user's cycling route, the decision that users should make a route public only using their mobile phone, the decision that users should not have complex account registration and login procedures on the web site, etc.

Step 2 – Design: The updated requirements as well as the introductory coding that took place in the first cycle resulted in changes in the initial system architecture. Examples of such changes in the architectural design include dropping the use of Estimote Stickers in favor of Estimote Beacons, because of lack of support from Estimote for the Android platform at that particular point in time, dropping a complex user management and authentication module on the web site, detailed definition of the web services that implement the synchronization and sharing of routes on the web site, etc. Finally, a fully responsive web design for the web site was crafted, based on a template.

Step 3 – Coding. Coding efforts took the best part of the second development cycle of the project. A complete project structure was drawn and all software components were programmed and integrated into a single solution. The web site was implemented along the template that was defined within the design step of the cycle and the web services were created and tested.

Step 4 – Test and Evaluation: Within the implementation phase, internal tests (without the participation of testers or users) where conducted. Tests included:

- Component tests, performed against specific software components, such as communication with Beacons, communication with the local database, operation of the Google Maps component within the application, correct storage of the route's points, correct operation of the web services, correct operation of the user interface of the web site, etc.
- Integration tests on the mobile device, which tested correct collaboration of the Beacon and GPS functions, so as to ensure that the application correctly calculates start and end of a route
- Integration tests across the mobile application and the web site, focusing mainly on the integration of the mobile application with the web services offered by the web site.

During these tests minor modification requirements and bugs were identified. These were addressed in the third and final phase of the project.

3.2.1.3 Cycle 3: Testing & evaluation phase

Step 1 – Requirements: The requirements step of the third project phase served only for the introduction of minor change requests and for the detailed registration of bugs. Examples of such requests were changes in user interface theme of the Android application, re-allocation of various user interface features from the home screen of the mobile application to the "Settings" screen.

Step 2 – Design: The design step of this cycle included only minor architectural adjustments, especially on the user interface of both the mobile application and the web site.

Step 3 – Coding: Within the coding step of the last project cycle, the minor change requests and bug fixes, previously identified, were implemented. In addition, a hosting environment was set up and the domain name "seniorscycle.co.uk" was reserved. The project code was installed on 5 Android devices and the web site code and database were transferred to the hosting environment in preparation for the final tests.

Step 4 – Test and Evaluation: The test and evaluation step of the final project cycle focused on the preparation, execution and evaluation of the workshop. These activities are described in detail in a separate section of the thesis.

3.2.2 Project Timeline

The table blow summarizes the actual timeline of the project, by specifying the start, and duration of each project phase. First and second phases took about 4 weeks each, whereas the implementation phase took twice this amount of time (8 weeks in total). The total project duration was just under 16 weeks (less than 4 months).

Table 1: Project Timeline

Date	***12/5***	***9/6***	***7/7***	***4/8***	***28/8***
Phase	**4 weeks**	**4 weeks**	**4 weeks**	**3,5 weeks**	
Initial Design					
Implementation					
Testing & Evaluation					

Important milestones of the project are noted in the list below:

- 12/05/2015. Project kick-off
- 09/06/2015. Completion of the initial design phase
- 04/08/2015. Completion of the implementation phase
- 15/08/2015. Organization of the workshop
- 28/08/2015. Project delivery and conclusion

3.2.3 Project steering and communication

The project was overseen by Dr. John Vines, the supervisor of the dissertation and Dr. Rachel Clarke.

Communication with the team was accomplished through regular meetings either in person or online via Skype. During those meetings feedback was offered both on functional and technical areas of the project. Focus was placed on continuous design improvement and refactoring, including regression testing, to make sure existing code has not been broken by the new additions.

The initial step of the project development includes a detailed review and critical evaluation of Background Material relevant to the project. This included a review of existing applications, products and digital services in this area, as well as relevant literature that can be a valuable asset towards the completion of the system. A set of initial research material was suggested by members of the project's team.

In regular intervals and especially after the completion of each meeting, a detailed report was submitted to the supervisor. In total, 11 reports were submitted within the project's time life.

3.3 Functional analysis – Use Cases

The list below summarizes the use cases that the system was required to implement and support. The use cases are organized on a per system component basis. Use cases UC01 – UC10 refer to functional characteristics of the mobile application, whereas use cases UC11 – UC15 refer to functional characteristics of the companion web site. For each group of use cases, the actors are initially identified. Each use case is

assigned a UC code and for each use case a description and a detailed set of execution steps are described.

3.3.1 Use cases for the mobile application

3.3.1.1 Actors

The main actors involved with the mobile application are:

User: The "user" actor stands for actual mobile application users, who have downloaded and installed the application on their mobile phone and have acquired an Estimote Beacon.

System: The "system" actor refers to the actual mobile application and is used to indicate automated behavior of the system which occurs without the need for any explicit user interaction.

3.3.1.2 Use Cases

Picture 8: UML Diagram

UC01. Check BTLE

Description

The system should check if the device supports Bluetooth Low Emission (BTLE) and refrain from continuing operation if BTLE is not supported by the particular device.

Execution Steps

1. The application is started.
2. The system checks if the mobile device has Bluetooth Low Emission (BTLE) functionality:
    a. If the mobile device is equipped with BTLE, then the application starts normally and presents the user with the opening screen;
    b. If the mobile device is not equipped with BTLE, then the user is notified accordingly and the application halts and exits.

UC02. Check BT & Location

Description

Upon starting the application, the user should be warned that the Bluetooth and Location services have been started. If they are not, the user should be prompted to start these services before proceeding with the execution of the application.

Execution Steps

1. The application is started.
2. The system perceives that either the Bluetooth service or Location service or both services has or have not been started.
3. The user is prompted to start these services:
    a. If the user selects to start the services, the application then the application starts normally and presents the user with the opening screen;
    b. If the user does not start the services, the application halts and exits.

UC03. User Identification

Description

The user should identify himself to the system on the mobile application.

Execution Steps

1. The user starts the application.
2. The user chooses to enter or modify her user name and password.
3. The user is presented with an appropriate data entry form.

4. The data entry form contains the currently registered credentials, which may be blank or filled in with previously entered credentials from the user.
5. The user enters or updates her user name and password.
6. The system is updated with the user's credentials.

UC04. Beacon identification

Description

The user should be able to select the Beacon that she uses on her bicycle.

Execution Steps

1. The user starts the application.
2. The user selects to identify her Beacon to the application.
3. The system demonstrates the Beacon that has been previously selected by the user.
4. The system starts "ranging" (looking) for available Beacons in its vicinity
    a. If the system discovers a set of Beacons it presents the list of Beacons to the user. For each Beacon the user is presented at least with the Beacon's MAC address.
    b. The user selects a Beacon from the list.
    c. The user's selection is stored and the system is aware that this proximity to this Beacon identifies bicycle use on behalf of the user.

UC05. Enabling Tracking

Description

The user should enable tracking of her routes by a clear choice on the mobile application.

Execution Steps

1. The user starts the application.
2. The user instructs the system to start ranging for the selected Beacon and listen for changes in the location (start tracking).

UC06. Identify and store routes

Description

The system should automatically identify start and end of a route and register with a local database different points within the route.

Execution Steps

1. The user has executed UC06.
2. The system starts listening for a Beacon, disregarding all Beacon signals that do not come from the Beacon that has been previously identified as the "user's Beacon" through UC04. At the same time the system listens for movement of the mobile device, through signals from the location service.
3. When the system pairs the Beacon with the Location signal for a sufficient amount of time, the system identifies the beginning of a new route.
4. While the system continues to receive Beacon signals, senses location changes and adds each new location as a new point on the user's route.
5. If the system stops receiving signal from the Beacon, it senses that the user has moved away from the bicycle and registers the end of the route.
6. The systems starts listening again for a Beacon (point 2 above).

UC07. View list of routes

Description

The user should be able to view a list of the routes that have been registered.

Execution Steps

1. The user is running the application.
2. The user selects to view a list of the routes that have been already registered by the system (UC06).
3. The system presents a list of routes. For each route, the system presents:
    a. The date that the route was registered.
    b. The time that the user starting following that route.
    c. The distance covered by the user.
    d. The average speed by the user.

UC08. View route on map

Description

The user should be able to view a route on an online map.

Execution Steps

1. The user has executed use case UC07.
2. The user selects a route.
3. The system presents a map of the route that the user selected.

UC09. Send routes to web site

Description

The user should be able to synchronize her routes to the online web site.

Execution Steps

1. The user has executed use case UC07 and is viewing the list of her routes on the mobile application.
2. The user chooses to synchronize all her routes to the web site.
3. All appropriate information is sent to the web site along with the user's credentials.
4. Routes are saved on the web site's database and are marked as private, so that only the user who synchronized the data can view the routes online.

UC10. Share a route online

Description

The user, from within the mobile application, should be able to make a selected route public for all visitors of the web site.

Execution Steps

1. The user has executed use case UC08 and is currently viewing the selected route on a map on her mobile device.
2. The user chooses to make the selected route public.
3. An appropriate message is sent to the web site through a web service
    a. If the route is already synchronized on the web site, it is marked as public, regardless of its previous public or private status.
    b. If the route has not been previously synchronized on the web site, it is sent over the web service and stored on the web site and it is marked as public.

3.3.2 Use cases for the web site

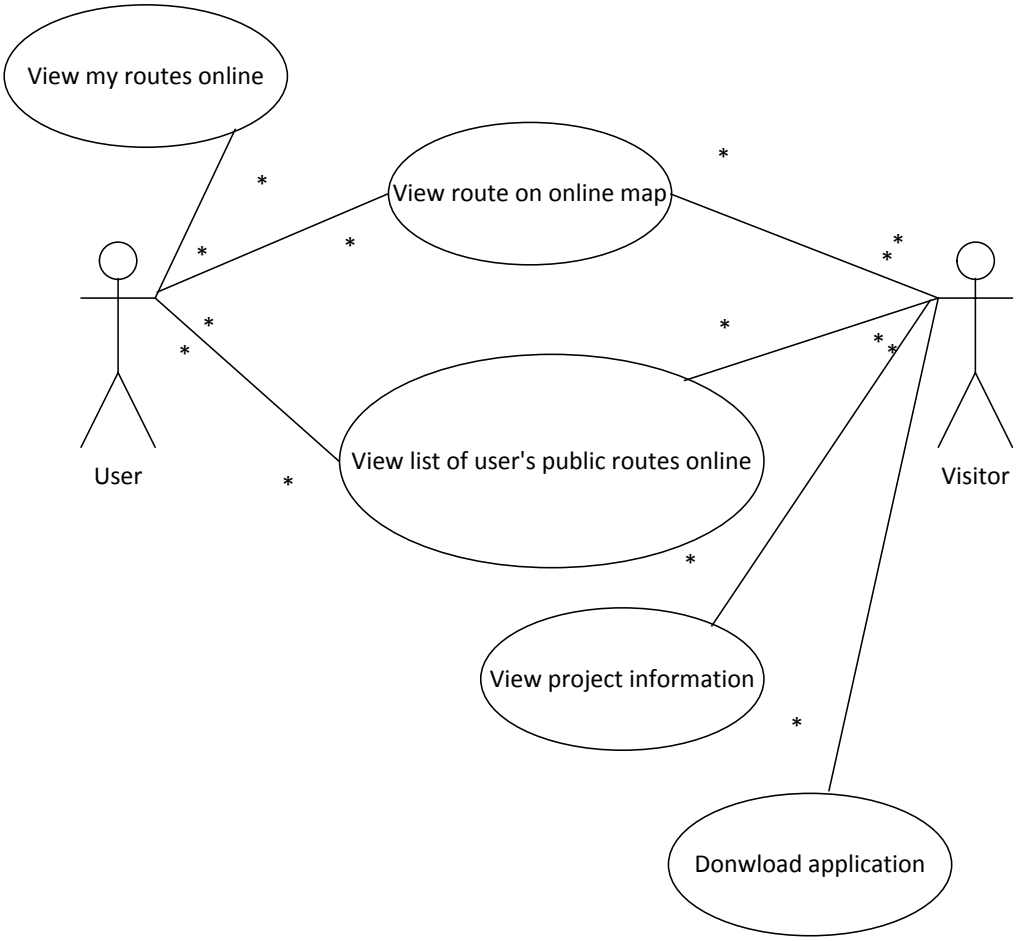
3.3.2.1 Actors

The main actors involved with the web site are:

User: The "user" actor stands for actual mobile application users, who have downloaded and installed the application on their mobile phone and have acquired an Estimote Beacon. As far as the "web site" is concerned, a "user" is a web site visitor who has set her user name or password on the mobile application and has synchronized her routes on the web site.

Visitor: The "visitor" actor refers to visitors of the web site who do not hold credentials on the mobile application and are thus not able to synchronize their routes on the web site, nor view any of their routes online. However, visitors may view public routes of users on the web site, provided they know the user's user name.

3.3.2.2 Use Cases



Picture 9: UML Diagram

UC11. View my routes online

Description

The user should be able to view the list of routes she has synchronized on the web site through the web site's user interface.

Execution Steps

1. The user uses her browser and navigates to the web site.
2. Through an appropriate choice (e.g. menu choice), the user is presented with a page that contain data entry controls for entering her credentials.
3. The user enters the credentials that she has already entered in the mobile application (as per use case UC 03).

4. The user is presented with all the routes that she has synchronized on the web site.

UC12. View route on online map

Description

The user or a visitor should be able to view on a map a route that she will select from a list of routes that are presented on the web site (visitors should be able to view only public routes).

Execution Steps

1. The user has executed use case UC11 and is currently viewing a list of her routes (both public and private).
2. The user selects a route and is presented with a representation of the route on an online map.

UC13. View list of user's public routes

Description

A visitor should be able to view a list of routes that another user has shared (made public) on the web site.

Execution Steps

1. The visitor navigates to the web site and chooses to see a user's public routes.
2. The visitor is presented with a web page that contains a data entry field where the visitor can enter the user's username.
3. The visitor types the user's username.
4. The visitor is presented with a list of all public routes that have been previously shared online by the user selected in the previous step (step 3).

UC14. View project information

Description

A visitor should be able to acquire information on the project from the project's web site.

Execution Steps

1. The visitor navigates to the web site.
2. The visitor chooses a web page that contains information on the project.

UC15. Download application

Description

A visitor should be able to download the mobile application from the web site and install the application on their mobile phone.

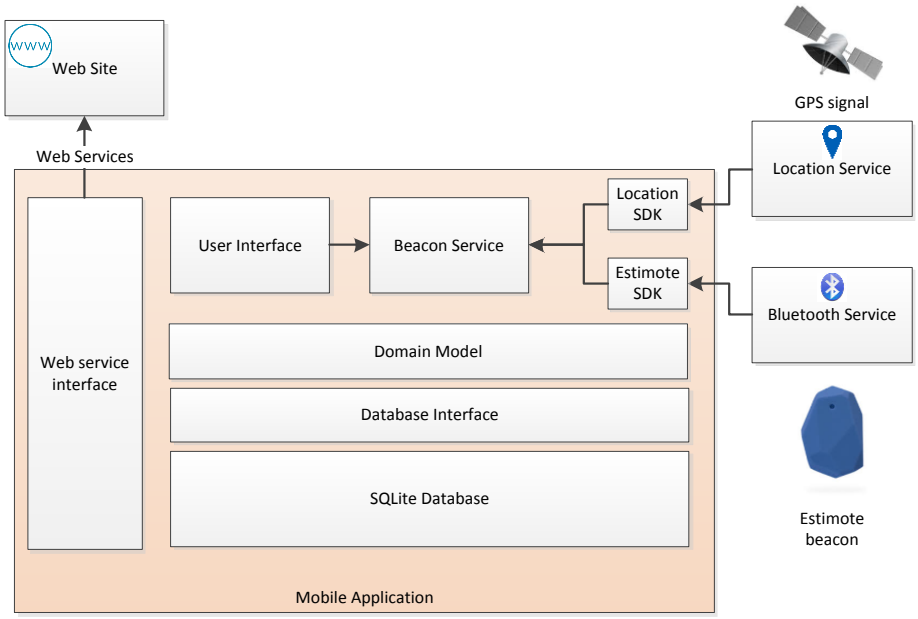
Execution Steps

1. The visitor navigates to the web site using the web browser of her mobile device.
2. The visitor chooses a web page that contains a download link for the application.
3. The visitor downloads the application installation file and installs the application on her mobile device.
4. By following the process specified in use case UC03 and by acquiring an estimate Beacon, the visitor becomes a user of the application.

3.4 Technical description of the Mobile Application

3.4.1 Architecture of the mobile application

The diagram below presents a concise view of the logical architecture of the Mobile Application.



Picture 10: Architecture of the Mobile Application

The mobile application interfaces with four external systems:

- **GPS infrastructure**, through the infrastructure provided by the native location service of the Android system
- **Estimote Beacons**, through the Bluetooth communication channel supported by the Bluetooth service that is native in Android.
- **The web site** that is part of the overall system developed within the current project, through a set of web services provided by the web site and consumed by a specific web service interface that is an integral part of the mobile application
- **Google maps service**, the mapping service available from Google.

The software libraries and SDKs that are used by the application in order to connect to the external systems mentioned above are presented in a following paragraph.

In the business logic layer of the application, data are abstracted and modeled through domain model entities, such as "User", "Point", "Route", "Beacon". These entities are used both within the user interface and the Beacon Service. In reality, all data are persisted in a mobile version of the SQLite relational database. Access to the database is provided through a database helper, a specific system component that encapsulates all database access actions. The database helper can persist and retrieve domain model entities to and from the database.

The core components of the system, the components that implement the actual business logic off the mobile application, are the Beacon service and the user interface.

The user interface includes forms and screens that are used to present information to the user (e.g. list of routes, list of available Beacons in the vicinity of the device, route on a map, etc) and collect information from the user (e.g. username / password, selection of user's Beacon and a few other similar choices)

The Beacon service handles incoming signals from Beacons and from the location service of the Android system. By combining these signals, it identifies routes and stores the routes in the database.

3.4.2 Domain Model

The domain model of the application includes the following entities / classes:

User

This class encapsulates data that identify the user of the mobile application. These data include:

- Username (email).
- Password.
- UserID (Unique Identifier).

KBeacon

This class encapsulates data that identify an Estimote Beacon:

- Beacon MAC Address.
- Major.
- Minor.

Of the three above, only the MAC address was actually used within the application.

Point

Points model actual geographic locations that are part of a user's routes. The "Point" class encapsulates the following information:

- Longitude, as reported by the location service.
- Latitude, as reported by the location service.
- Altitude, as reported by the location service.
- Time, as reported by the location service (refers to the time that the relevant data on the point were acquired from the location service.
- User, being the user of the mobile application whose geographic location is recorded or managed in any way within the application.
- Route, being the user's route in which the point is actually part of.

Route

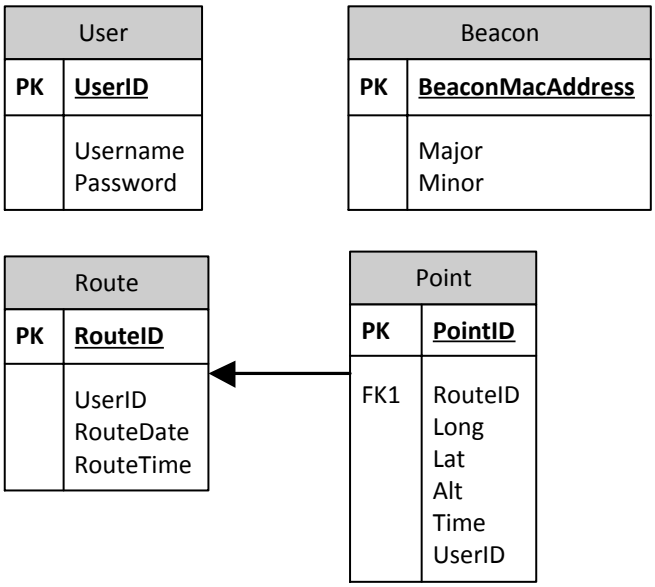
Routes model the actual routes that are registered by the application. For each Route, the following information is maintained:

- User, who has made the route (refers to the user of the mobile application).
- Route Date, being the date that the route's recording started.
- Route Time, being the time that the route's recording started.
- Route Distance, is the total distance that the user cycled within the route
- Average speed.
- Route Points, a collection of all points (geographic locations) that belong to the particular route.

Apart from accessor methods (getters / setters), Route objects also encapsulate methods for calculating the total distance and the average speed, based on the geographic data of the points that belong to the route.

3.4.3 Database

The database of the mobile application serves as a repository for entities that belong to the domain model that was described above.



Picture 11: The Database structure

In general the entities are independent of one another, apart from the Point and Route entities, which are joined by a foreign key relationship.

The database used was SQLite. When the application starts, if the database does not exist, it is created from scratch and its tables are empty.

Access to the database is provided to the business logic of the application is provided through the **BeaconSQLiteHelper** component, a custom class that extends the default component provided by the Android SDK class. The component used includes methods for setting and accessing user, Beacon, point and route information from the database. Example methods include addRoute (to insert a route in the database), addPoint (to insert a point in the database), getAllRoutes (to get all routes saved in the database), getPoints (to get all points for a specific route), getRoute (to load all data for a route with a specific route id). BeaconSQLiteHelper also includes code for setting up the database (for the first time – if the database does not exist) and for clearing the database from all data.

3.4.4 User Interface

The user interface consists of a set of five activities which correspond to the five screens of the mobile application.

3.4.4.1 Main Activity

This is the main activity of the application. It includes four buttons:

- **Settings button**: for showing the "Settings" screen;

- **My Routes button**: for showing the user's list of routes;
- **Current Location button** for showing the user's current location on a map and
- **Let's cycle button** for starting the BeaconService.

Picture 12: The Main Activity

The main activity of the application also includes startup code that

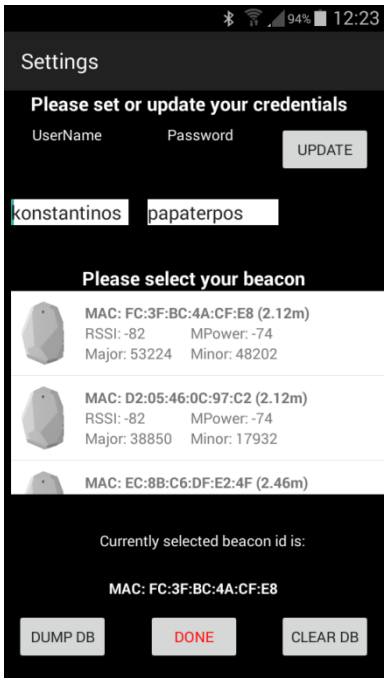
- Checks if the device is equipped with Bluetooth. If not, the program is gracefully terminated, after the user is appropriately informed.
- Checks if the location service on the mobile device is enabled. If not, the user is prompted to enable the location service on her mobile device.
- Checks if the Bluetooth service on the mobile device is enabled. If not, the user is prompted to enable the Bluetooth service on her mobile device.

Picture 13: Pop up message on start

- Checks if the user has already selected a Beacon. If not, the user is prompted to go to "Settings" and set his Beacon and credentials

3.4.4.2 Settings Activity (ListBeacons Activity in the source code)

This activity presents the "settings" options that are available to the user.



Picture 14:The Settings Activity

Such options include:

Selection of Beacon:

The application, using the Estimoted Beacon SDK, listens for Beacons in the vicinity of the device. The data collected for each Beacon is automatically added in a List. This list in turn is "fed" into an auxiliary construct call "BeaconListAdapter". The BeaconListAdapter is an extension of Android's BaseAdapter and is used in managing the data shown by a ListView control (device_list), which is included in the activity's layout. In other words, the activity's layout includes a ListView which is bound to a BeaconListAdapter, an extension of Android's BaseAdapter. The adapter is filled in with Beacons discovered. This is done by the RangingListener of the BeaconManager, which is a class implemented in the Estimote Beacon SDK. The way that the BeaconListAdapter gets is values from the Beacons discovered by the Ranging Listener of the Beacon Manager is shown in the following code snippet:

```
private BeaconManager beaconManager;
private BeaconListAdapter adapter;
beaconManager = new BeaconManager(this);
beaconManager.setRangingListener(new
BeaconManager.RangingListener()
{
  @Override
  public void onBeaconsDiscovered(Region region, final
List<Beacon> beacons) {
    runOnUiThread(new Runnable() {
      @Override
      public void run() {
        adapter.replaceWith(beacons);
      }
    });
  }
});
```

Whenever a user clicks on a Beacon within the ListView, the Beacon's MAC Address is stored in the Database as the currently selected Beacon for that particular user.

The currently selected Beacon's MAC address is shown in a simple TextView of the Setting's activity layout.

Identification of User:

The settings activity includes two text boxes where the user can see and update her username and password.

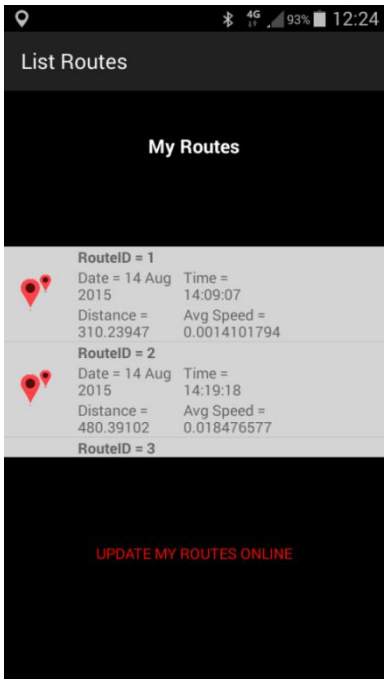
Auxiliary Actions:

The settings activity also includes two buttons:

- One can be used for clearing all data from the database of the mobile application.
- The second can be used for moving the database actual file to a specific folder (on the SDCard) of the device. This is done because on a non-routed phone, the location of the database file is inaccessible. By transferring the database file to another location, it is possible to access the database file, transfer it to a PC and examine the contents of the database through an appropriate SQLite management piece of software.

3.4.4.3 ListRoutes Activity

The list routes activity is used to display a list of routes registered in the database. All routes of the current user are displayed.



Picture 15: The ListRoutes Activity

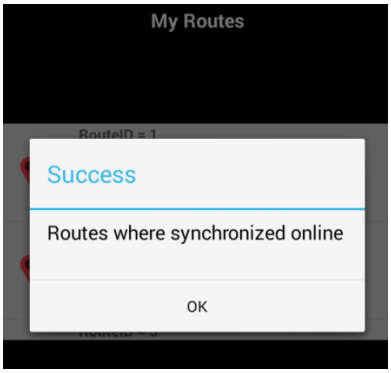
The activity includes a ListView which in turn is bound to RouteListAdapter, a class that extends Android's BaseAdapter. The logic and implementation are similar to the BeaconListAdapter presented above. However, in this case the list that feeds the adapter is retrieved from the database through a call to the BeaconSQLiteHelper class.

```
BeaconSQLiteHelper db = new BeaconSQLiteHelper(this);
ArrayList<Route> routes = db.getAllRoutes();
if (routes != null){
    adapter.replaceWith(routes);
}
```

By clicking on an item that is included in the list, the user is taken to the MapRouteActivity, described below. The call to the MapRouteActivity includes the ID of the route as well as all the points that belong to that particular route.

The activity also includes a button that synchronizes all routes from the local database to the Web site through the appropriate web services, which are described below. In order to access the web services provided by the web site, the code at this point utilizes a WebUIRouteSynchronizer.

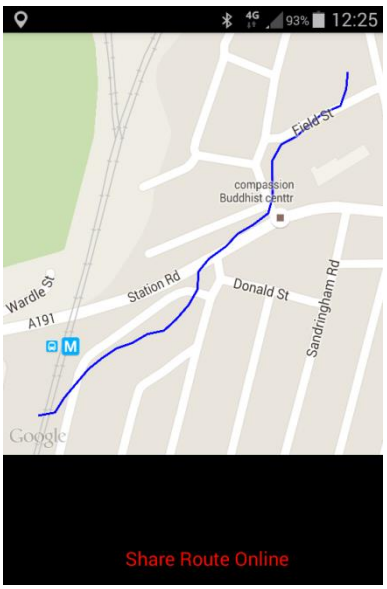
```
btnSyncRoutes.setOnClickListener(new View.OnClickListener() {
    public void onClick(View v) {
        WebUIRouteSynchronizer wbs = new
WebUIRouteSynchronizer(sURL,
       ListRoutesActivity.this);
        String s1 = "";
        wbs.execute(s1);}});
```



Picture 16: Pop up message informing that routes synchronized successfully

3.4.4.4 MapRoute Activity

The MapRoute activity presents a route's points on an online map.



Picture 17: The MapRoute Activity

It is always called with a route's id and points in its intent (routeID and mapPoints respectively). These are stored within class fields. As soon as the activity is loaded, a map is drawn and a polyline that consists of the route's points is drawn. This is implemented within the drayPolyLineOnMap method. When the map is done loading, a command is issued for the map to center and pan so that the route that has been drawn can fit fully into the map area shown.

```
mMap.setOnMapLoadedCallback(new
GoogleMap.OnMapLoadedCallback() {
    @Override
    public void onMapLoaded() {
        fitMapToRoute(mapPoints);
    }
});
```

The MapRoute activity also includes a button that publishes a route on the web site, by using the WebUIRoutePublisher class and providing the class with routeID of the route that is currently being displayed.

3.4.4.5 Current Location (MapsActivity in the source code)

The CurrentLocation activity (MapsActivity in the source code) is a simple map activity that gets the user's current location from the location service and displays this location on a google map.

3.4.5 Beacon Service

The Beacon Service is the second, after the user interface, core component of the mobile application.

The Beacon service utilizes two main components: a Location Manager, which manages location information from the location service and a **Beacon Manager**, which can listen to and respond to signals from Beacons.

The source code overrides the default behavior of each of the above managers by defining new listener functions, so as to define what should happen when a change in location is sensed and when a signal from a Beacon is detected:

- Location changes are handled by the onLocationChanged method of a new LocationListener class, which is associated with the Location Manager.
- Respectively, Beacon signals are handled by the onBeaconsDiscovered method of the ranging listener that is attached to the Beacon Manager.

Location changes and detection of Beacon signals are combined in a simple algorithm which tries to identify if a new route has been started and which stores points belonging to the route into the database.

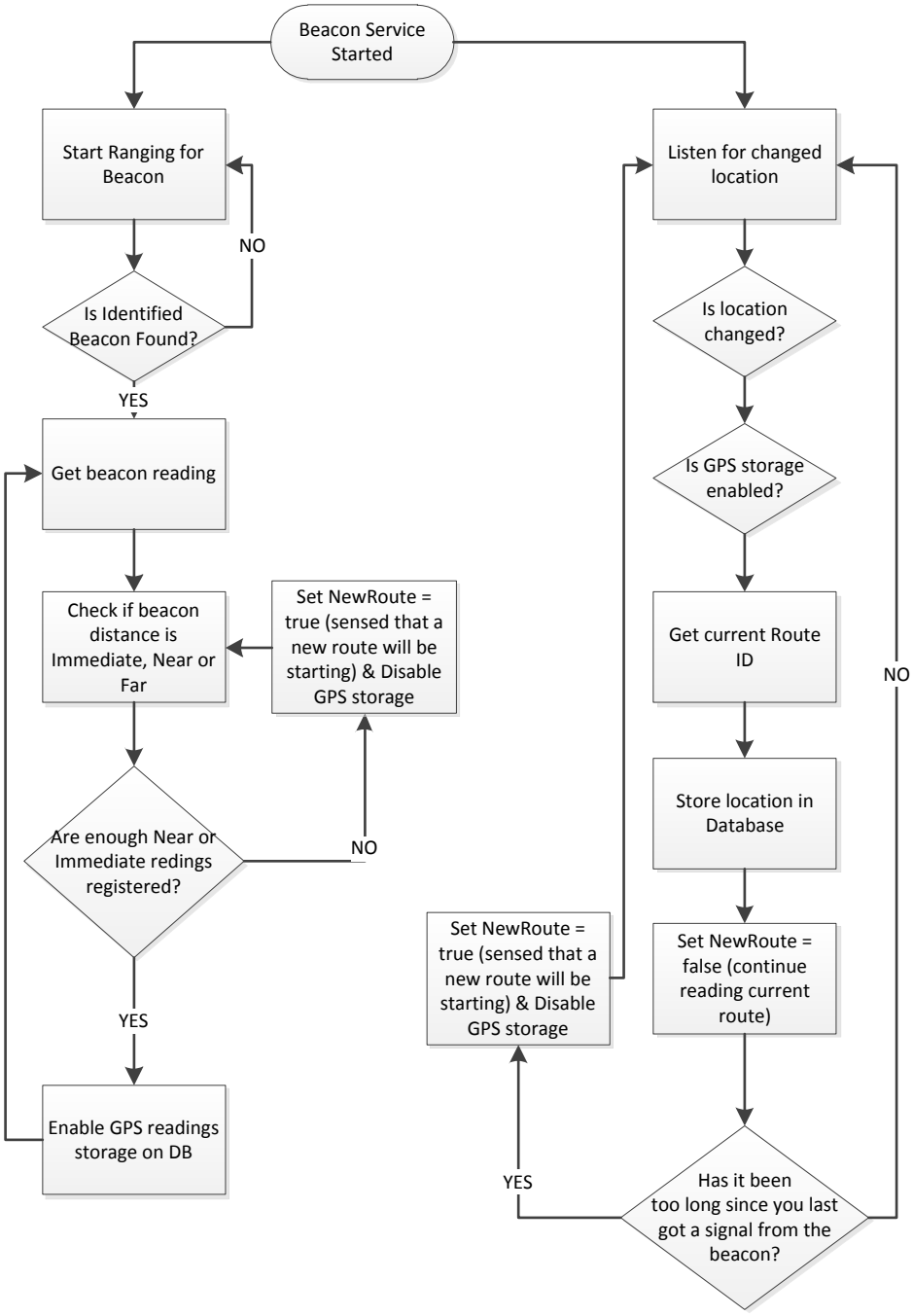
The algorithm is presented in the following diagram. In brief, whenever Beacon signal is detected, the service:

- Identifies if the signal comes from the Beacon which has been selected as the "user's Beacon" in the Settings activity;
- Checks if the Beacons proximity is Immediate, Near or Far, as reported by the Estimote SDK.

When the number of Immediate or Near readings exceeds a threshold, the service senses that the user is close to the Beacon (and the bicycle) long enough to mark the start of a route. So it creates a new route and enables storage of location points.

When the number of Immediate or Near readings drops and conversely the number of Far readings exceeds a threshold, then the service senses that the route has finished (the user has dismounted her bicycle), marks the end of the route and prohibits the location manager from storing anymore location data in the database.

At the same time, the location listener is activated whenever change in location is sensed. If GPS storing is enabled, the point detected is stored in the DB and is associated with the current route (that has already been marked as "new" by the ranging listener of the Beacon manager).



Picture 18: Sequence Diagram

The location listener also checks, whenever location is changed, if there has been a very large time interval from the last Beacon reading. If a threshold has been exceeded, the route is considered completed (a new route is prepared) and GPS storage is disabled.

The result of this algorithm is the identification and storage of routes and points in the database, when the user is riding her bicycle.

3.4.6 Web Service Interface

The Web Service Interface consists of three classes:

- WebUIRouteSynchronizer.
- WebUIRoutePublisher.
- WebServiceCaller.

WebServiceCaller is a simple class that contains a single method, exchangeData, which can post a set of parameters to a specified URL and handle the response from the web service. If the response status from the web service is valid (e.g. 200 – OK), then the response data are encoded into a JSON Object and are returned to the method that originally called exchangeData.

WebUIRouteSynchronizer is an Android Async Task extension. It can start and run alongside the UI thread of the application. Before starting its actual work, it displays a progress bar.

When it is executed (doInBackground method), it follows the steps described below:

- It collects all routes that have been registered by a user (by calling the getRoutes web service);
- Then it loads from the database all the user's routes;
- For each route that has not already been uploaded, it calls the RegisterRoute web service, in order to send the route's data to the web site.

WebUIRoutePublisher works in a similar fashion. However, its goal is to upload information only for a specific route. The web service itself (RegisterRoute) checks if the route is already persisted. If yes, its status is updated to "Public", otherwise it is added in the web site's database as a "Public" route.

3.4.7 External SDKs & Libraries

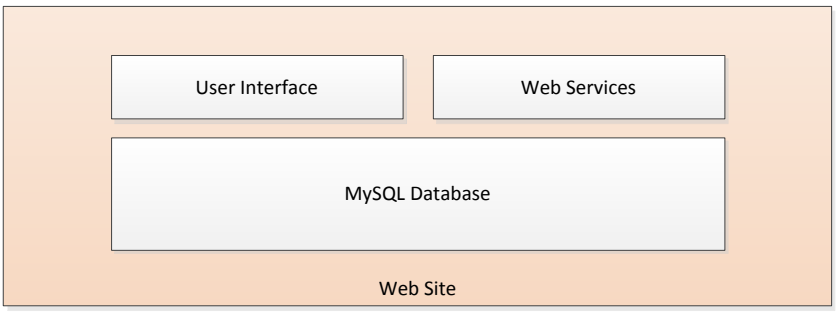
Software development kits and libraries used include:

- Estimote SDK;
- Google Maps SDK (through Android.Location service);
- HttpURLConnection and associated classes from java.net;
- SQLiteOpenHelper from Android.database.sqlite.

3.5 Technical description of the web site

3.5.1 Architecture of the web site

The web site was implemented as a standard PHP web site. Data are persisted in a MySQL database and are accessible to the rest of the code through the typical SQLi interface.



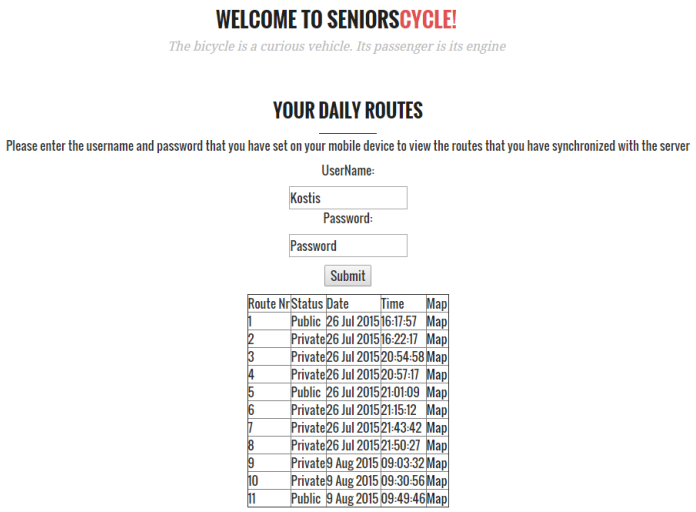
Picture 19: Web site structure

The PHP code is organized into a user interface section and a web service section.

3.5.2 User interface

The user interface section includes a home page (index.html) and two pages for searching for and viewing routes:

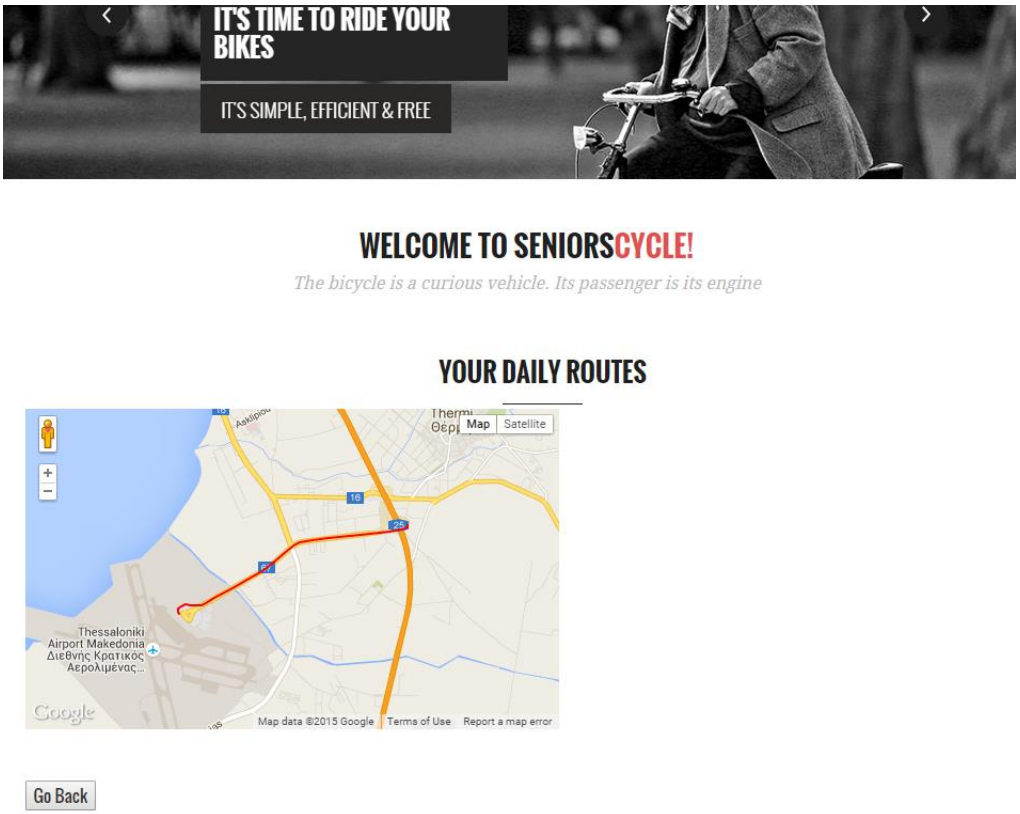
Routes.php enables a user of the application to search for her routes by entering her username and password on the page. The list of the user's routes that have been synchronized on the site appears.



Route Nr	Status	Date	Time	Map
1	Public	26 Jul 2015	16:17:57	Map
2	Private	26 Jul 2015	16:22:17	Map
3	Private	26 Jul 2015	20:54:58	Map
4	Private	26 Jul 2015	20:57:17	Map
5	Public	26 Jul 2015	21:01:09	Map
6	Private	26 Jul 2015	21:15:12	Map
7	Private	26 Jul 2015	21:43:42	Map
8	Private	26 Jul 2015	21:50:27	Map
9	Private	9 Aug 2015	09:03:32	Map
10	Private	9 Aug 2015	09:30:56	Map
11	Public	9 Aug 2015	09:49:46	Map

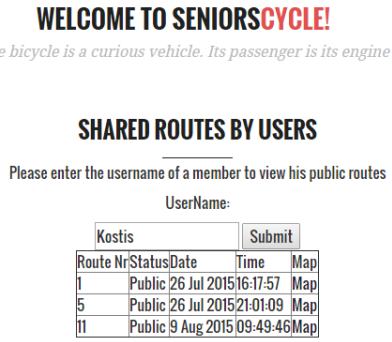
Picture 20: My Routes

By clicking on a route's "map" link, the user s presented with a map of the specific route.



Picture 21: Map of the route

Community.php is a second page that displays all routes that a user has made public. The web site's visitor enters the user's name and a list of the public routes is displayed.



Picture 22: Community

Again, by clicking on the "Map" link, the route is displayed on an online map.

3.5.3 Web Services

The web site integrates a set of web services. Each web service expects input through form submission. The form must include a "json" parameter. The web service expects this to contain all input encoded as a json object. Each service returns its results in the form of a json object.

The web services implemented include:

existsRoute.php

Expects as input a route id, username and password. Searches to check if the specific route has been registered by that user.

getRoutes.php

Expects a user's username and password. Returns all routes registered on the web site under this username and password. For each route, route points are not included in the response.

registerRoute.php

Expects all data related with a route, namely:

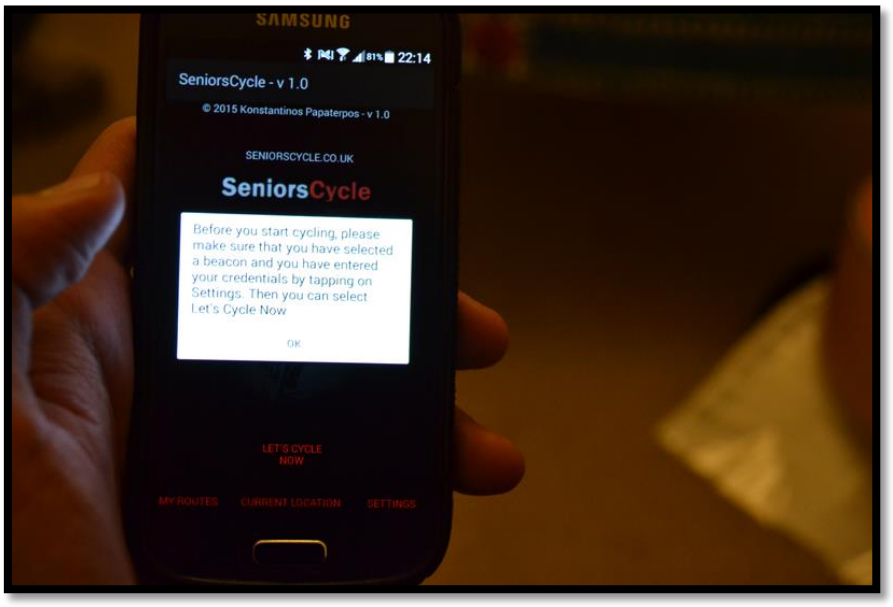
- Username and password of the user submitting the route.
- ID and features of the route being submitted (isPublic, data, time).
- All points (as an array) that belong to that route.

This web service creates and stores a route with all data presented above in the web sites database. If the route exists and the user's request specifies that the route should be registered as public, it updates its status into "Public".

3.6 Fictional Scenario

Scene 1

Scene 1: The fictional character of the scenario is called A.I, 56 years old. He has been cycling for the past four months and he has not tried any similar applications before. He owns a Samsung S4 Mini and downloaded the application from the web site.

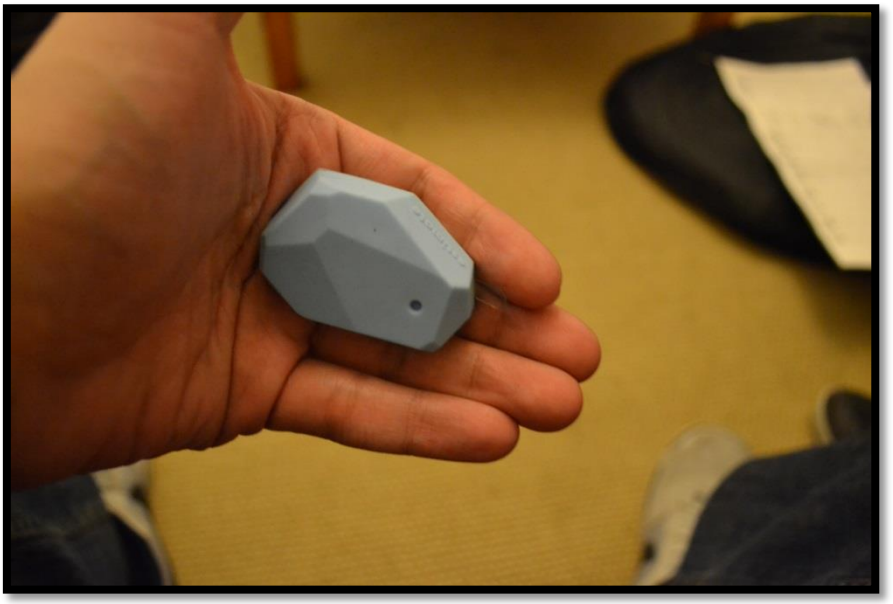


Scene 2

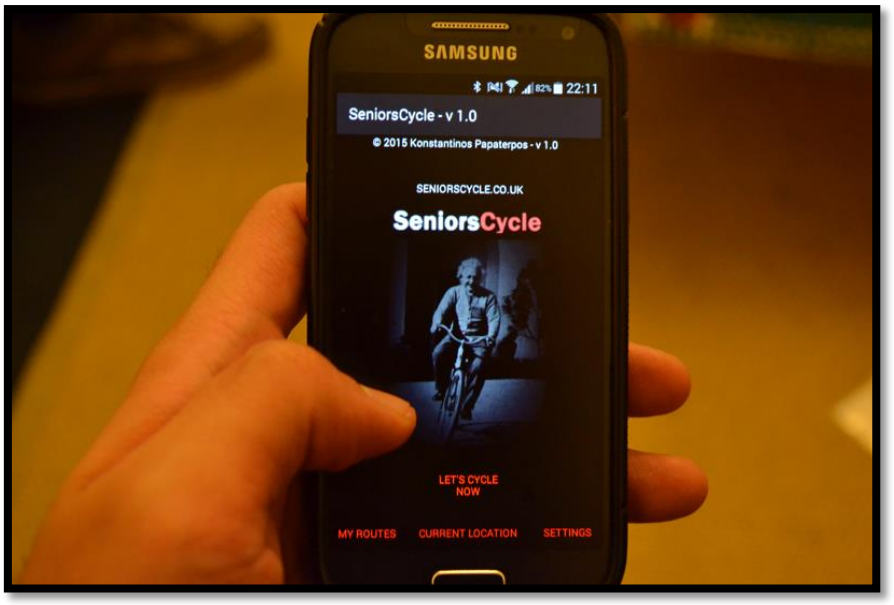
Scene 2: The first step is to open the application. A pop up message appears on the screen informing A.I that he needs to open the Settings screen, select a Beacon and enter his credentials.

Scene 3

Scenes 3 – 4: A.I opens the pack he purchased online that contains the Estimote Beacons and picks the one he wishes to use with his bike. Estimote Beacons are small devices that can be attached to objects. They use Bluetooth technology to broadcast radio signals and communicate with the user's smartphone.

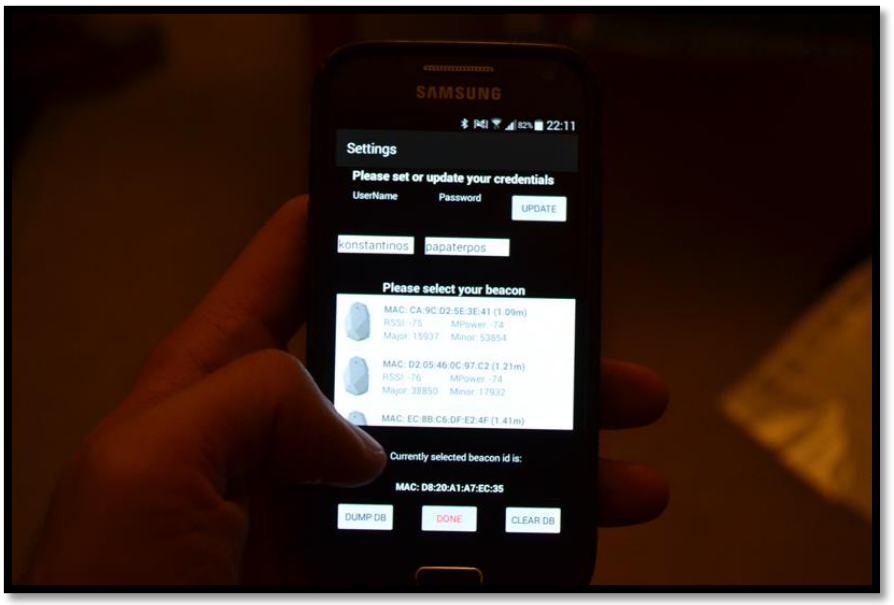


Scene 4



Scene 5

Scene 5: A.I taps on OK and the pop up message disappears. He has the Beacon next to him and now he can set up an account by selecting the "Settings" option.



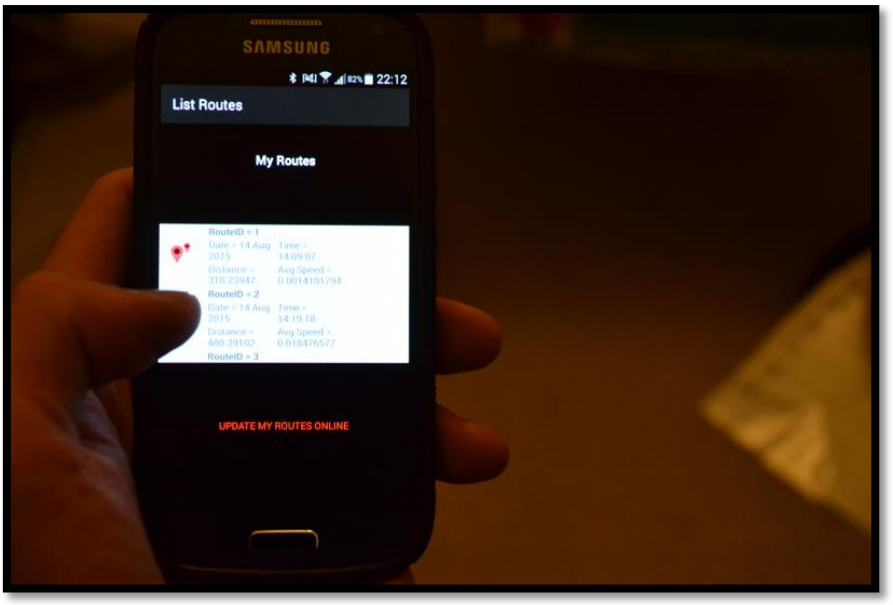
Scene 6

Scene 6: The next step is to enter his username and password, tap on "Update" and then select the Beacon that will use.

Scene 7

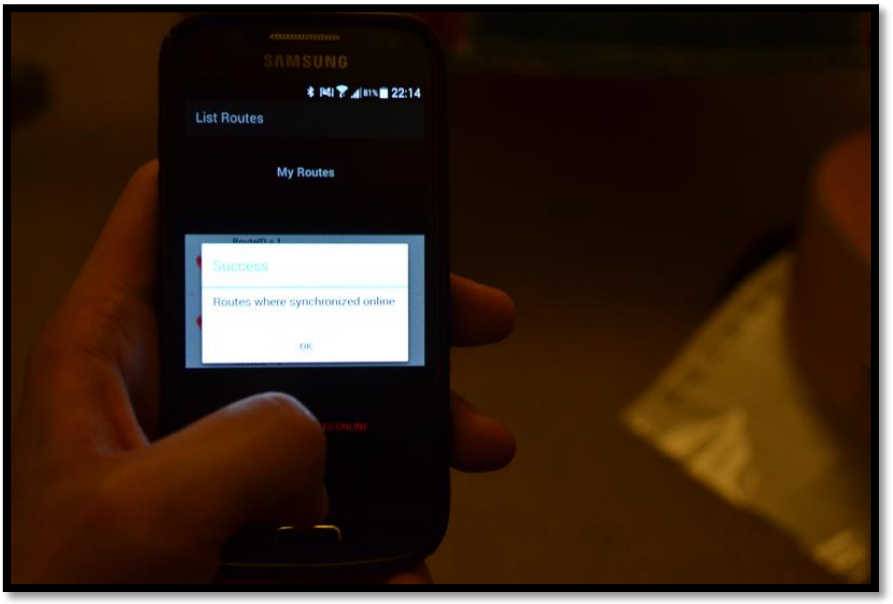
Scenes 7 – 8: A.I attached the Beacon on his bike. The only thing he has to do now is to keep his phone in his pocket without switching the GPS or the Bluetooth off.

Scene 8



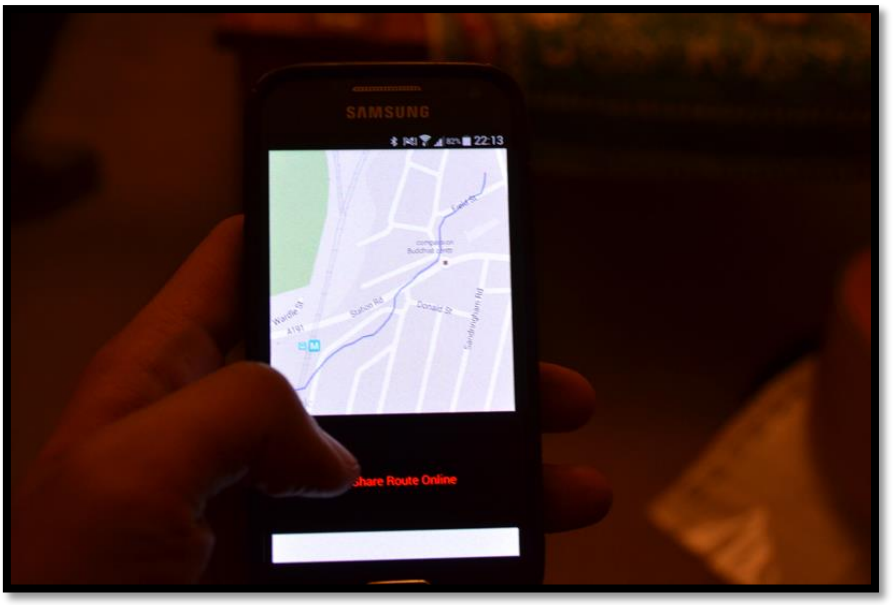
Scene 9

Scene 9: A.I completed his ride and selected to view the history of his routes by taping "My Routes". He can see a list of the routes with relevant data and he can either tap on a specific route to see the route shown on a map or update his routes online and view them on his laptop.



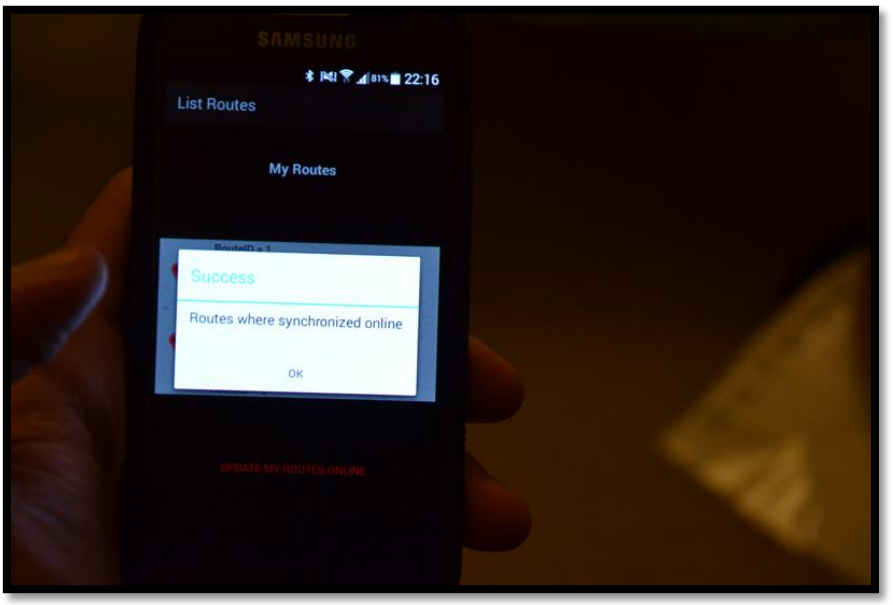
Scene 10

Scene 10: The routes that are stored locally on his phone and the routes online are now synchronized.



Scene 11

Scene 11: A.I views the route he selected and he can either share it online with other members of the community or keep it private.



Scene 12

Scenes 12 – 13: A.I shared the above route online and whoever knows his username can access the route only.

Scene 13

4. Results & Evaluation

This section mainly includes the results of the evaluation of "SeniorsCycle" with a group of older adults who were relatively new or returning to cycling. The section consists of a brief description of the workshop procedure, questionnaire results and discussion of the efficiency, usability and accessibility of the system. The workshop procedure includes details on the recruitment strategy, introductions to participants, presentation of the application, cycle ride trial, uploading of routes, an open discussion and completion of a questionnaire. This chapter also includes a peer observation, the results of the survey some key findings and some points of the Background – Technical Material that are verified through the system. At the end of the chapter one can find two detailed tables with all the actions that were performed during the Testing process for both the mobile application and the web site.

4.1 The Workshop

In order to validate and evaluate the efficiency, the usability and the accessibility of the system, a workshop was organized on August 15, 2015 by Dr. Clarke, Wilbert Den Hoed and Konstantinos Papaterpos as part of the MyPlace[2] project. The workshop took place at the Cycle Hub[3], a café, bike hire and bike repair shop on Newcastle Quayside. This location was chosen to provide an informal place to start the workshop that was recommended by MyPlace partners and was familiar to many of the participants. The location also provided easy access to a range of cycle routes that included on and off road routes for different abilities.

Picture 23: Workshop, 15/8/2015

[2] www.myplace.ac.uk
[3] http://www.thecyclehub.org

4.1.1 Recruitment

Recruitment took place three weeks prior to the workshop. Flyers were given to small groups of people on the "Why Weight" programme, "Bike Right" scheme and "This Girl Can" scheme organised through Newcastle City Council at the Cycle Hub. These programmes encourage a combination of community activity around everyday exercise, cycle proficiency and social rides. Promotion also took place on Facebook and Twitter, and was promoted through The Elders Council through their email distribution list and through their "Information Now" web site. We provided lunch and a £10 shopping voucher for those taking part.

A total of 17 people expressed an interest in coming to the workshop but it was decided to cap this at 11, in order to keep the workshop manageable due to the space and equipment limitations. However, people that could not be accommodated were informed about upcoming workshops in the near future. All those contacting us about the workshop were given an information sheet detailing the aims and objectives of our research, a consent form, a schedule for the workshop and an 'Expression of Interest' form to fill in prior to attending the workshop.

4.1.2 Workshop introductions

Nine of the anticipated 11 showed up to the session together with an unexpected participant. Participants arrived at different times, the majority of whom had been to the venue in the past and had already filled in the required documents. Having completed the setup of the equipment an introductory friendly conversation followed. People introduced themselves highlighting their interest in cycling, although many of them had not cycled in a long time or had just started and were coming to sessions via different programmes. Health (both physical and mental), more sustainable transport, meeting new people and visiting new places were some of the reasons people described as motivations for getting into cycling.

4.1.3 Presenting the Application

During the presentation of the system (mobile application, web site, Beacon) some concerns were expressed about using the application for older people who may not have confidence or access to particular kinds of equipment. Some additional explanations about the role and the operation of the Beacon were also given while paper handouts with screenshots of the application were distributed to people in order to guide them through the process of what they would see on screens and how to set up their devices.

4.1.4 Cycle Ride

The most complicated part of the workshop was the cycling part where participants had to cycle and test the application in real life conditions. To save time and simplify

the process, because of the large numbers of Beacons, the phones had already been set up with stored credentials and a matching Beacon. One small group stayed in the carpark and another group led by a more confident woman – who has been training to be a cycle leader – went across the Millennium Bridge. This was significantly enjoyed by the group.

Picture 24: Getting ready to cycle along Newcastle's Quayside

4.1.5 Uploading Routes, Discussion and Questionnaires

The final part of the workshop included the upload of routes on the web site followed by a group discussion and a series of questionnaires. Open questions asked specifically to each individual around the table and most of them focused on their relationship to technology, mobile phones and social media, the usability of the system, their usual cyclist activity and the probability of using the application again in the future. An exact copy of the questionnaire can be found in the Appendix (§ 7.5).

4.1.6 Peer Observation

The main purpose of the introduction and the group discussion was to examine the relationship of the participants with cycling, technology and the extent to which they have adjusted to the requirements of the digital era. The majority of the participants were recently inactive and had started cycling after a long period of time for different

reasons. R. S, 54 years old, said: *"I'm trying to lose some weight. My husband's a very keen cyclist and he's super fit and I've never been able to keep up with him. Now we can go out and cycle together".* Other participants are about to start cycling again. For example, S. W, 63 years old said: *"Never was I allowed to ride a bike and I always wanted to"* and J. L, 67 told the group that *"I haven't done it for a few years, so I thought it would be a good idea".*

Some other people are keen on cycling again but are afraid of the cars on busy roads. A.N, 58 years old, said: *"I was keen on riding since I was six years old. I've stopped cycling while I was a teenager. I don't like to go on the streets with those cars. I'm scared and I need to regain my confidence"*. Similarly, A.T, 56 years old, added: *"I have got a bike, but I haven't been on it for a long time. I'd love to cycle to work, but it's on the A1 which is a nightmare".*

The workshop participants seemed genuinely interested in the system. Most of them said that they would use the app and share their journeys or use it after they learn how to cycle. They seemed to understand the functionality of the app correctly and to recognize its simplicity because it integrates only features that they find useful. One of the participants, R.S, 54 years old, mentioned that she has been using Strava and Endomondo for a long time but she would be more than happy to start using "SeniorsCycle", since Strava is regarded *"too technical and hard to read on the screen"*. The participant also said that she only wants to know data such as distance, time and route. *"That for me is a great tool. I am already familiar with the technology because I had been using it in the past while I was running",* she said.

A part that the majority of the people were enthusiastic about was the ability to see where others go and post/read additional comments on places/routes. They believe that it would be very informative for future rides because they often struggle to cycle on the roads, to obtain their current location, to find cycle-friendly routes, to recommend routes, etc., all of which can improve their confidence on the road. The application can clearly fill a need for essential information for beginner cyclists, and makes it easier for new cyclist groups (such as the ones the female participants were involved in) to keep in touch and share experiences in a straightforward way. J.A, 54 years old, said: *"Because I am leader I would like to share where I am going, so people could join me, or see where I have ridden. I do share photos on Facebook anyway, so I would like to use an All–in–one package with privacy settings because I would not want everyone to see what I share. It would be a really useful tool".* More or less, participants are very happy to share routes, along with photos, videos and written reports that may be added when the application is updated and become available for iOS. As long as the sharing happens with friends and fellow cyclists, privacy seemed not to be an issue. Quite a few participants already use Facebook, which may help the sharing among a wider group of people. The particular group of "new" cyclists, by definition experiencing and learning new things, seems to be eager to share these experiences and learn from peers. This is something the app – and sharing journey data in general – facilitates, as well as the opportunity to socialise and

getting to know new people. Participants clearly expressed they would be happy to find out where to cycle peacefully and how to arrange activities with other people, joining others for cycling rides or organising rides themselves.

However, some participants said they were not very familiar with technology such as computer and smartphones. For example one of them had a smartphone but did not know how to use it and her son is the one who installs apps for her. Using the app – or any app in general – could be problematic for them, although they seemed motivated to keep up with the others and become more familiar with using a smartphone. "I do cycle quite a lot but as regards this technology I'm a dinosaur I'm afraid", C.M, 65 years old, said.

Also, it seemed that different opinions were presented about the use of a Beacon installed on the bike: some thought the Beacons were unnecessary when already having a smartphone; others were concerned that they would forget to switch on the app before getting on the bike or would not at all take their phone when on the bike. The majority though is in in favour of an automated procedure in which the user views relevant data and routes.

4.1.7 Questionnaires Results

4.1.7.1 Section A

The first section of the questionnaire includes five Yes/No questions regarding to the relationship of the participants to today's technology and covers areas such as smartphones, smartphone applications, Internet access at home, mobile Internet, social media and GPS navigation. **These questions aimed at understanding the level of technology the participants use in everyday life.**

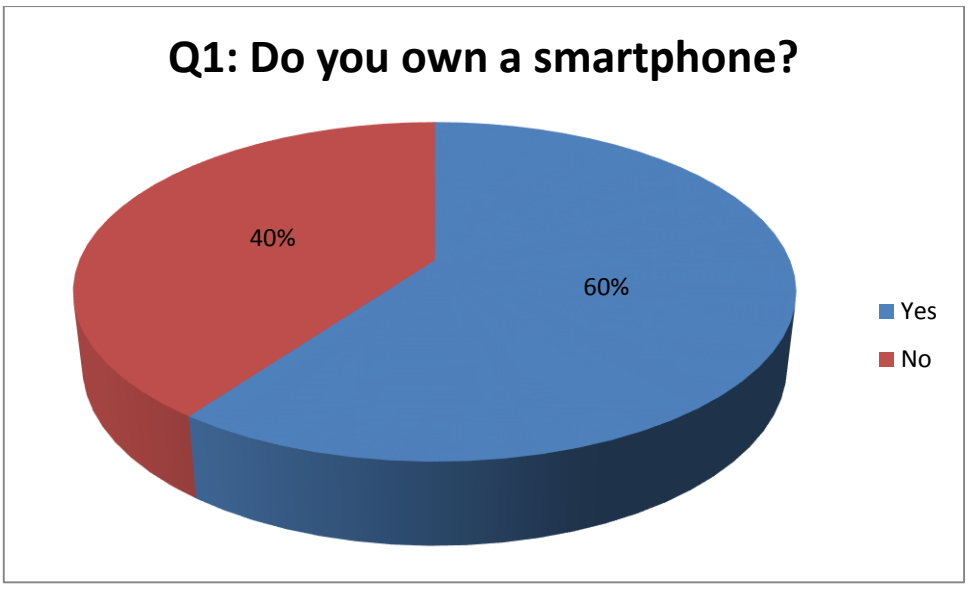


Figure 1: Section A, Question 1

During the group discussion all of the participants said that they are aware of the term "smartphone" and according to the questionnaire 60% of them own one. This is perfectly reasonable since (Stakeholders.ofcom.org.uk, 2015) by "the first quarter of 2011, around half of new handsets sold were smartphones". Nowadays (*Ofcom - The Communications Market Report*, 2015), "93% of UK adults said they had a mobile phone in the first quarter of 2015. Of these, 71% said they had a smartphone; 66% of the adult population".

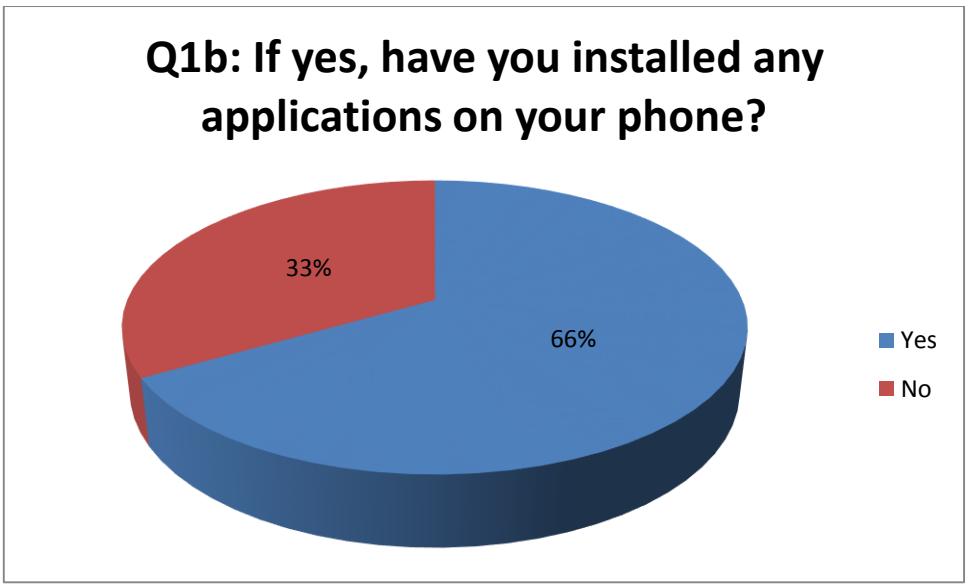


Figure 2: Section A, Question 1b

Despite the variety of functions that smartphones provide to the users a large part of them said that they have not installed any applications on their phones. All the participants that selected "No" as an answer said that they do not know how to install and use applications. Some of those who use them already said that their children installed applications on their behalf.

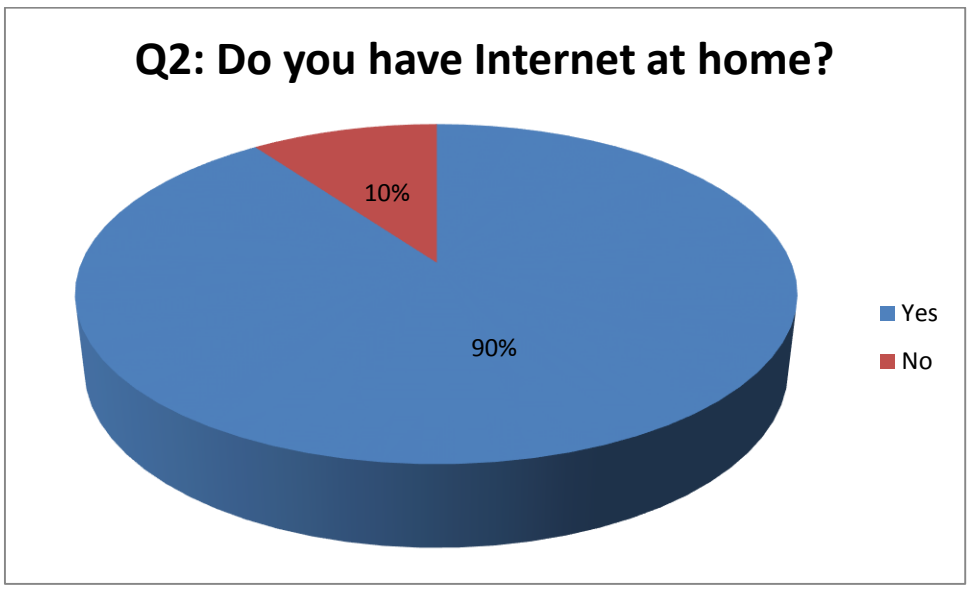


Figure 3: Section A, Question 2

The outcome of this question was perhaps unexpected since almost everyone said that has a broadband connection at home, since (*Internet Access - Households and Individuals*, 2013) "in Great Britain, 21 million households (83%) had Internet access in 2013", including younger adults. A percentage between 50% - 70% was initially expected.

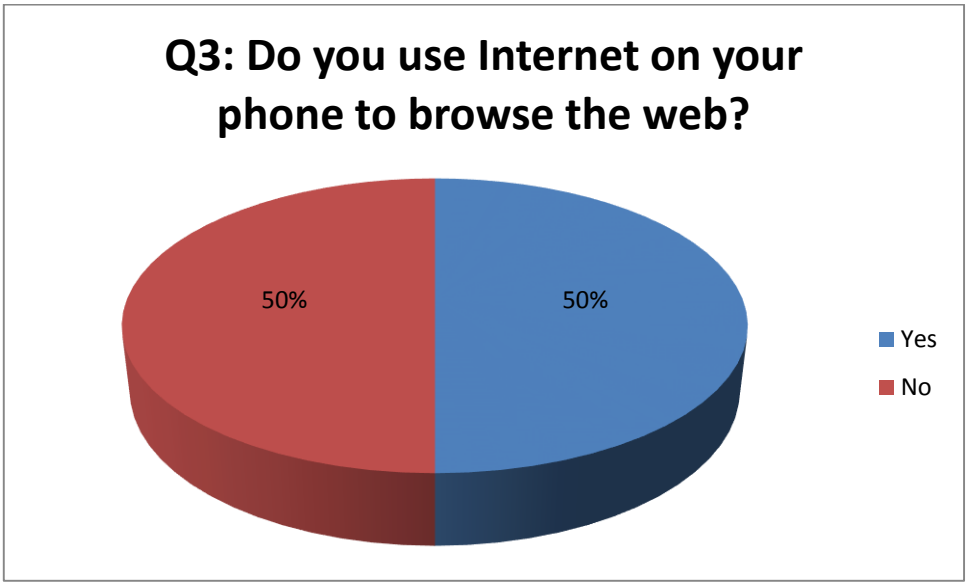


Figure 4: Section A, Question 4

Half of the participants answered that they use their mobile phones to access the Internet. This impresive percentage can be justified by the considerable increase in smartphones sales. It is worth mentioning that (*Internet Access - Households and Individuals*, 2013) "access to the Internet using a mobile phone more than doubled between 2010 and 2013, from 24% to 53%".

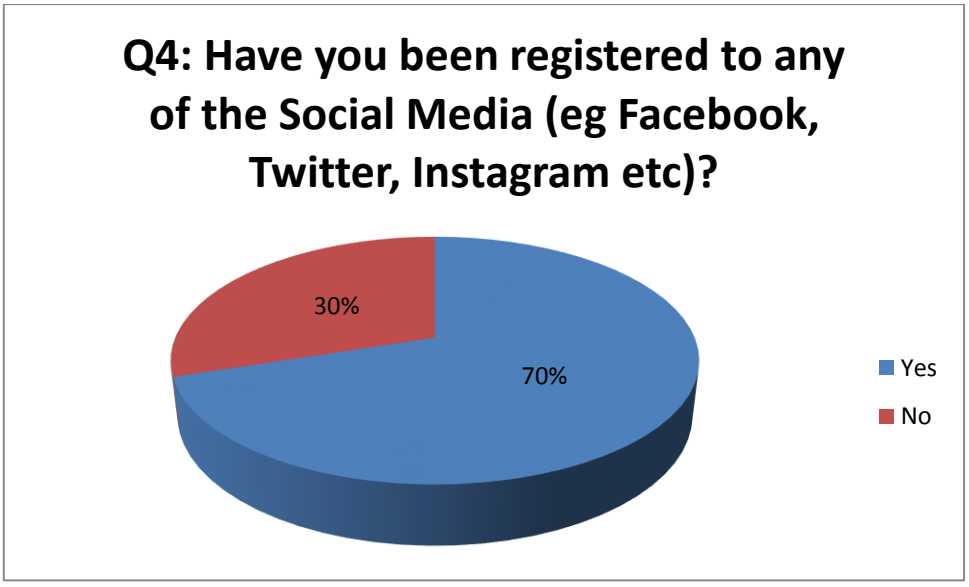


Figure 5: Section A, Question 4

The majority of the participants said that have been registered to Social Media platforms. Among them Facebook seemed to be the most popular and regarding to cycling it helps them organize trips with other senior adults and communicate with each other.

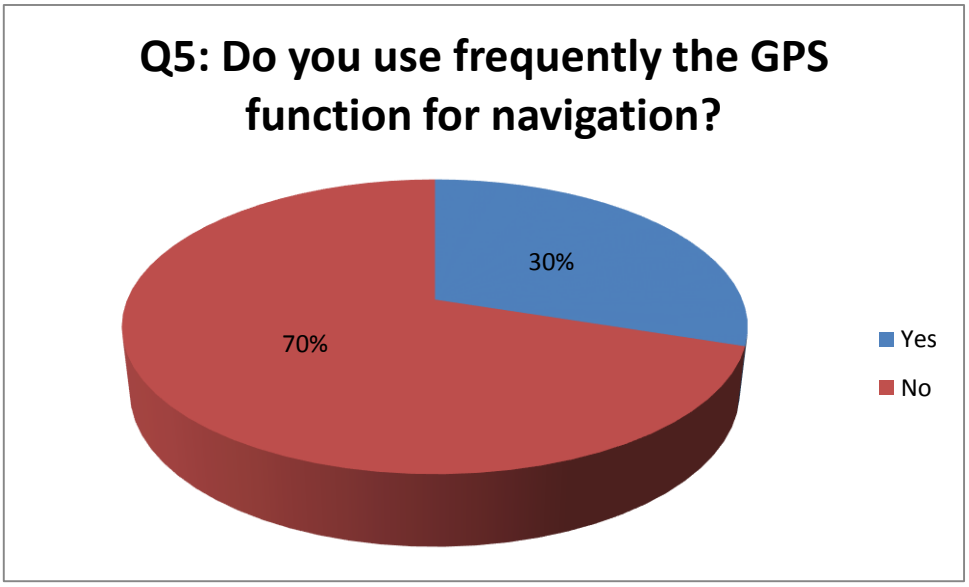


Figure 6: Section A, Question 5

Despite the fact that all participants were aware of the GPS technology and some of them knew services like Sat Nav, only 30% of them use it regularly for navigation. However, some of them may use it through their smartphones but without being aware of its contribution.

4.1.7.2 Section B

In this section the questions were **relevant to the system's usability** and participants were asked to evaluate how useful, difficult and likely is to use the mobile application. The possible answers vary from "Extremely" to "Not at all".

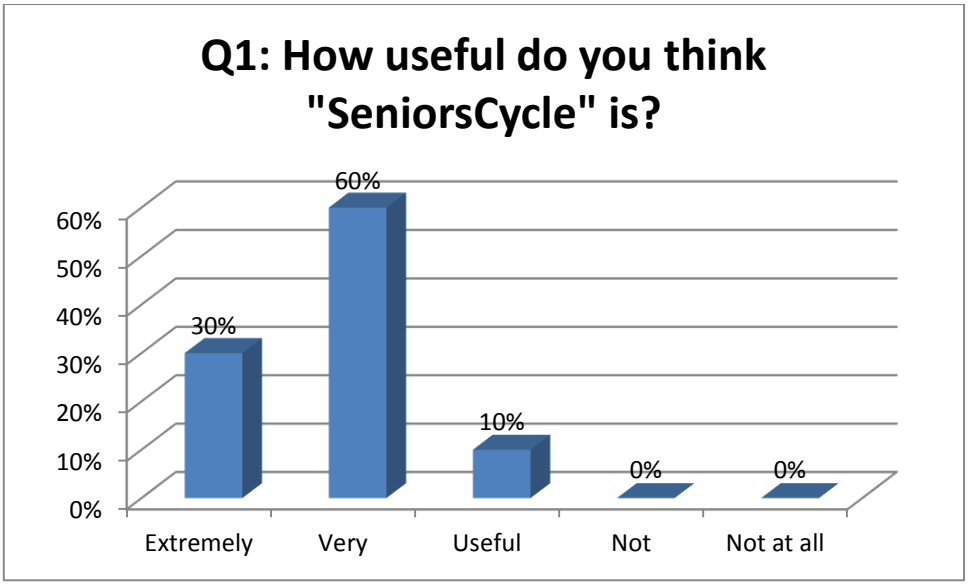


Figure 7: Section B, Question 1

The results of the first question are quite encouraging for the aim of the system. All the participants think that the system is at least useful, while 90% of them characterize it at least as very useful.

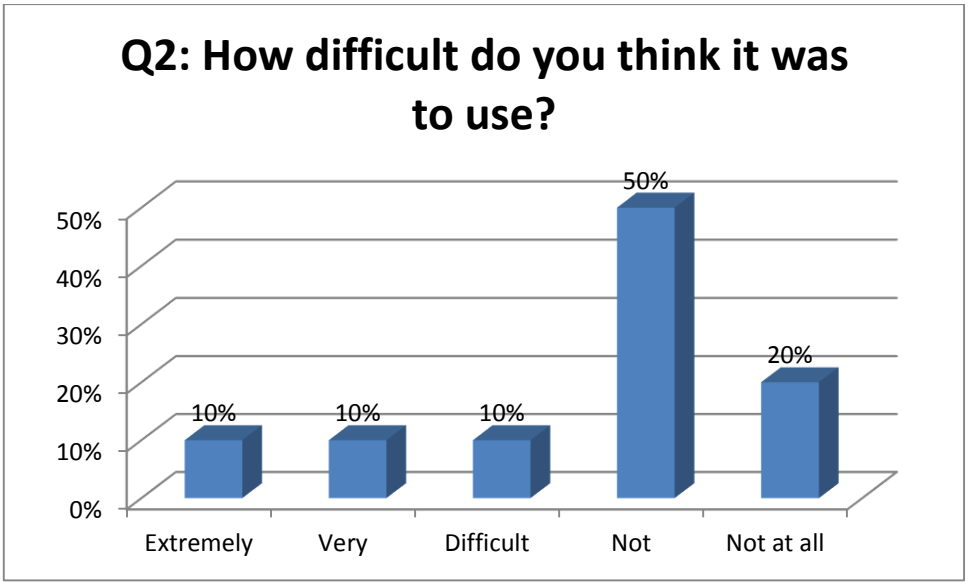


Figure 8: Section B, Question 2

The given answers prove that the early prototype of the application is usable for most people. 70% of the participants believe that that the operation of the application is not complicated, however the following versions should be simplify the process. The fear of new technological habits may be responsible for the number of people who do not feel comfortable using the application. In addition, a follow up meeting may convince them about the usability of the application and change their point of view.

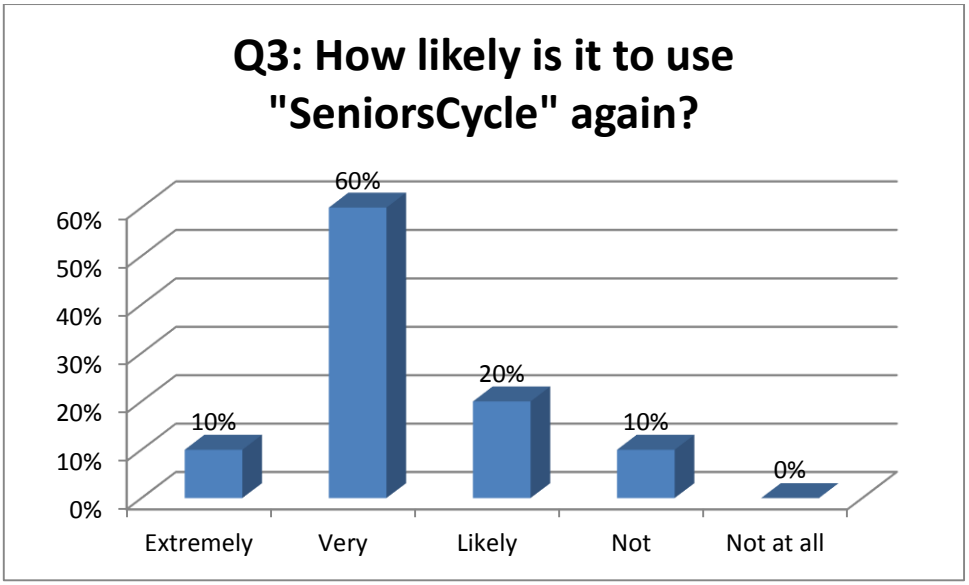


Figure 9: Section B, Question 3

Similarly to the first question of Section B, 90% of the participants are at least likely to use the application in the future. Undoubtedly, this question is closely related to the usability of the system and the needs of each user.

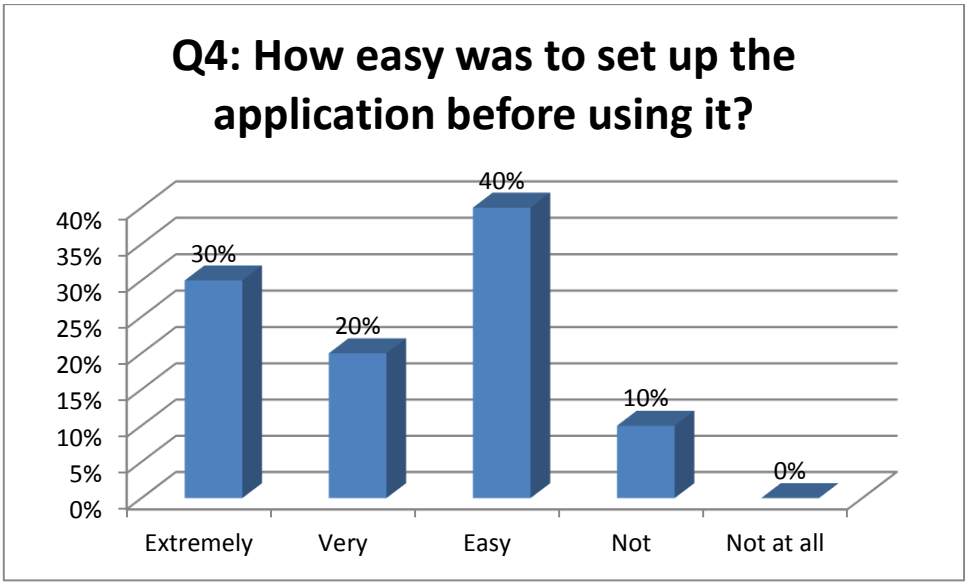


Figure 10: Section B, Question 4

As mentioned above, due to time limitations and the large numbers of Beacons that were in the room, the phones had already been set up with stored credentials and a matching Beacon. The stored credentials were used later on to share the routes online and show them on the web site. However, during the introduction there was a demonstration of how to enter the desirable username, password and select the right Beacon.

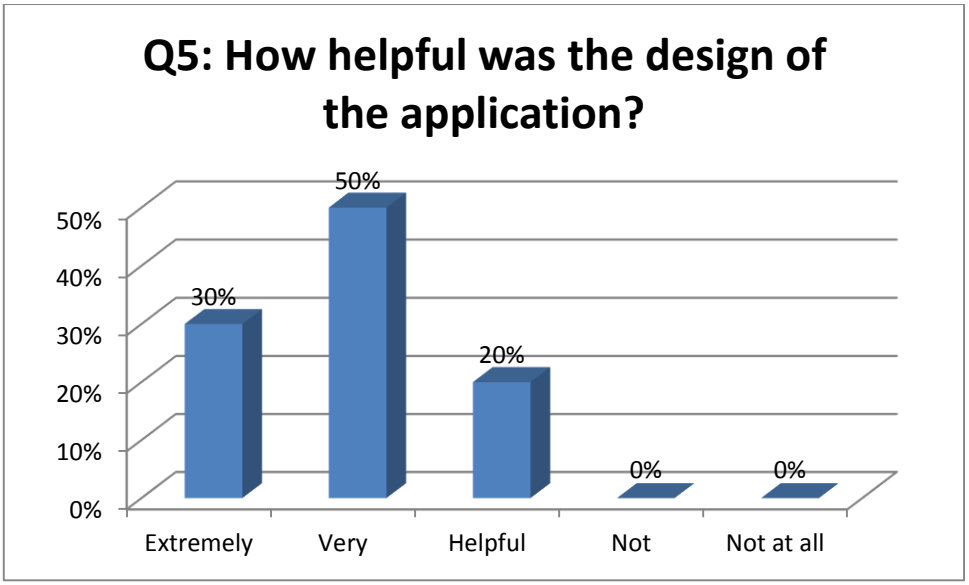


Figure 11: Section B, Question 5

A very important element of the application's usability and accessibility is the User Interface and the whole design. None of the participants believe that the design is not clear enough or misleading in any way.

4.1.7.3 Section C

This section contains a question about the most useful function of the application and two more questions **for possible changes in future editions of the application**.

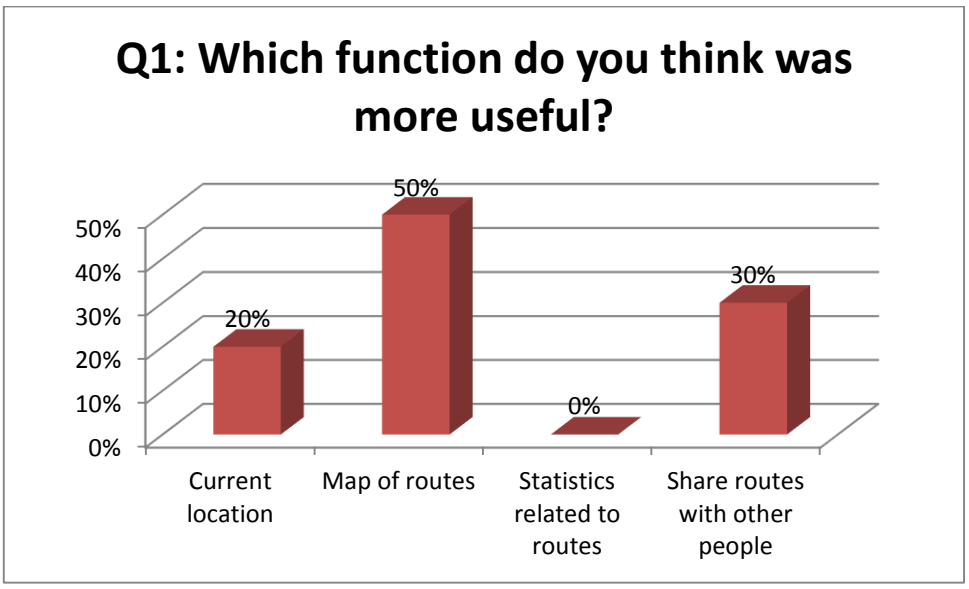


Figure 12: Section C, Question 1

This question represents the most useful functions of the application. Half of the participants find the map of routes as the most useful element but it is worth

mentioning that 30% of the participants consider the social aspect of the system as highly useful and consequently important.

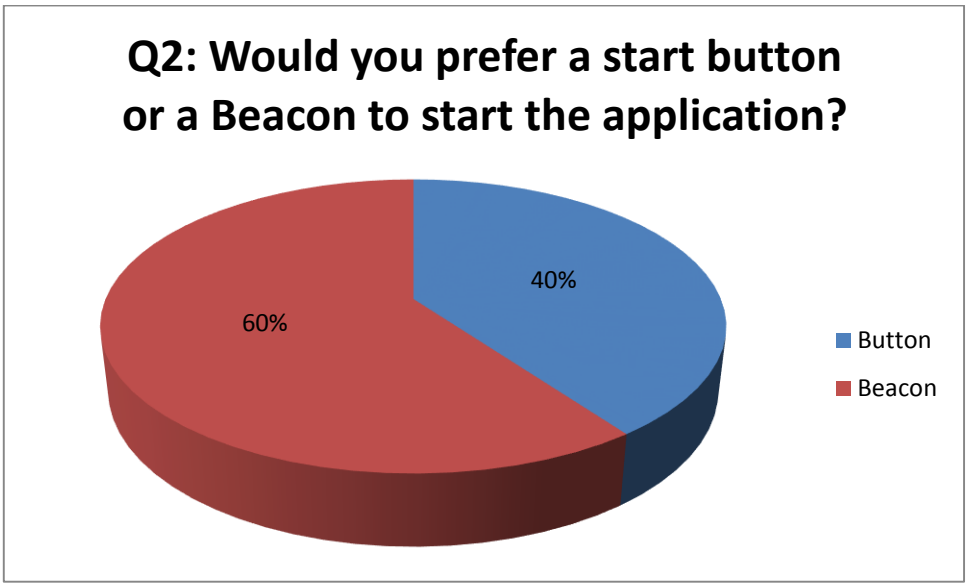


Figure 13: Section C, Question 2

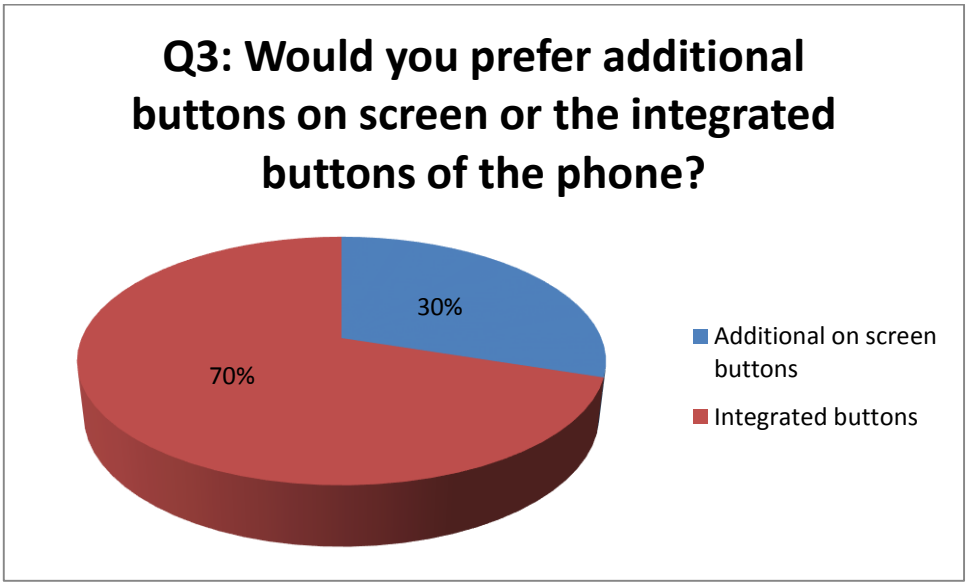


Figure 14: Section C, Question 3

Regarding to the last two questions of the section, the majority seem to have a slight preference on the Beacon and the phones integrated buttons, rather than a start button and any additional buttons on the screen. The above preference shows that the automatization of the system is a priority for the participants.

4.1.7.4 Section D

In the last part of the survey the participants were given the opportunity to share their thoughts about the application and their experience in general (50 – 150 words). Some

of the most interesting opinions **that prove the success and the usability of the system** are quoted below:

"Would like to use and share routes with friends. I think it would work for me. I enjoyed my experience today".

"I would like to use this app to help me find and share routes with other beginner cyclists. I have a bicycle but have lost my confidence a bit. This will give me the confidence to cycle on my own and with others. I do not know any cycle routes so this would be really useful for me. Thank you for a great morning".

"Enjoyed meeting up with people with a common interest. It was interesting listening to why the app was invented. It's good to know that I can access this information. I have an iPhone and I would like to put it on. I would like to use it with a Beacon and would like it to show (monitor) my statistics".

"I really enjoyed both the talk and the ride and I feel a lot more confident about it. I would find it really useful using the app if I could. It was explained well, so I think I could get into it".

"Very interested as I would like to find more people to go on bike rides as I am just learning to ride. The app would be very useful to me to share routes with others".

4.2 Key Findings

Participants Characteristics

- The majority of the participants were recently inactive and have started cycling after a long period of time for different reasons. Only a couple of them are learning how to ride a bicycle at the moment.

- Some participants said they were not very familiar with technology such as computer and smartphones. However, based on the questionnaires, the majority of them have Internet access at home, own a smartphone and have already installed applications on their phones. In addition, they do not seem to use the GPS frequently or their phones to browse the Web but they are registered at least to one of the social networks.

Usability of the System

- All participants were interested in the application while 90% of them rank it at least as "Very Useful". They seemed to understand the functionality of the app correctly and to recognize its simplicity because it integrates only features that they find useful. Half of them consider the map of routes as the most useful function.

- The vast majority believe that "SeniorsCycle" is easy to set up and use because of its helpful design.

- Most of the participants said that they would use the app and share their journeys or use it after they learn how to cycle. There was only one participant who is unlikely to use the application in the future.

- Quite a few people expressed their concern about cycling in busy roads and need to regain their confidence back. Some of the difficulties they experience include obtaining their current location, to finding cycle-friendly routes and recommending routes.

- Many participants were enthusiastic about the ability to view other people's routes accompanied by comments and multimedia content. They would be happy to find out where to cycle and arrange group rides with other people to different places. However, they prefer a one-to-one communication with people they know, rather than a broad community.

- Some participants said that the Beacons might not be necessary since they must keep the smartphone on them while cycling. However, the majority (60%) are in in favour of an automated procedure and would not prefer any additional on screen buttons (for example a START / PAUSE / STOP button).

4.3 Correlation of work done with presented literature review

As described in Chapter 2, the target group of the system consists of senior adults. The particularity and the nature of the target group impose a respective design that will facilitate the user's experience. According to Alan Dix (2004) learnability is one of the basic usability principles and can result to a maximal level of performance. The mobile application attempts to achieve a high degree of predictability by providing buttons at the same position in every screen. This feature combined with the consistent dark background of the screen provides the user with a feeling of familiarity.

In addition, the button labels are always red and have the same font to enhance the users' familiarity and memorability by helping them to predict future actions. The integrated back button of the phone is the main feature of synthesizability and helps the users to assess effects of past actions and occasionally take corrective action (recoverability). At some points, for example when the users enable the application, a pop up message appears on screen to inform them about the actions that need to be followed. This dialog initiative is highly important for the flexibility of the system but it was considered high risk to use it in a many circumstances. These messages are used in most cases as warnings or confirmations in favor of the required responsiveness. However, the application must remain simple and not extremely

sophisticated. In any case, the application follows the standards of multi – threading software and allows the user to run several other applications at the same time (eg listening to music while cycling). Furthermore, the Beacon makes a part of the process automated since the user does not have press on a start, pause or stop button.

In terms of communication patterns it is safe to say that the behavior of the users can be described as spontaneous and autonomic (§ 2.6), since the application ensures their anonymity. A large number of people during the workshop expressed their concern about the fact that they wished to share information exclusively with people of their choice. The web site ensures that shared content is not available to everyone and users can associate only with people who are aware of their username. Anonymity also serves the main principles of privacy, as a visitor of the website is obliged to enter a username. There is no list to obtain any possible usernames and in the future the privacy settings will include the user's encrypted password to enhance privacy and security. The system also complies with the fact that older adults are more interested in one-on-one communication than mass communication to a broader audience (§ 2.8), since the rest of the users do not have access to someone else's records, unless he / she wishes so. Some participants were keen on sharing their routes with members of the community in order to organize group rides, but the majority seemed to be interested in sharing information with specific people only.

Other similar commercial products, Endomondo for instance can be used for various sport activities and provide the user and his followers with real-time GPS tracking and live map, advanced statistics, audio coach feedback and other social activities such as competition between friends and sending multimedia messages to other users. The workout screen is customizable and features like pace, heart rate, calories and auto-pause tracking are also included in the app. Similarly, Strava provides a wide variety of features aiming at motivation and camaraderie even for people that exercise alone. The main disadvantage of Endomondo and Strava is SeniorsCycle's main advantage: the simplicity of the user interface that can be even more efficient in the following updated versions. This was something that was confirmed by a participant during the workshop. As mentioned previously (4.1.6), R.S, 54 years old, said that that she had been using Strava and Endomondo for a long time but she would be more than happy to start using "SeniorsCycle". *"Strava is too technical and hard to read on the screen. I am only interested in knowing data such as distance, time and route. That for me is a great tool. I am already familiar with the technology because I had been using it in the past while I was running",* she said.

4.4 System Testing

The functionality of both the Application and the Web site were tested during the workshop. To complete the testing six mobile phones in total were used; a "Samsung S4 Mini – i9591" and five "HTC One" running on Android version 4.4.2. The following tables are structured according to the Testing procedure of Software

Engineering and summarize the functions that were tested, the expected result, the actual result and some additional comments that can be used in updated versions.

4.4.1 Mobile Application Testing

To be tested	Expected result	Actual result	Comments
Start the application	A pop up message with instruction appears	Expected result	
Start the application while Bluetooth is off	Bluetooth permission request	Expected result	User turns Bluetooth on
Start the application while Location is off	Mode: Location services disabled	Expected result	User turns Location on
Open Settings Activity	Settings Screen appears	Expected result	
Enter credentials	Credentials are stored	Expected result	
Select a Beacon	Selected Beacon is stored	Expected result	
Dump Database	Database filed is copied on the phones root directory	Expected result	
Clear Database	Database records are deleted	Expected result	
Select “Let’s cycle now”	Android service starts	Expected result	
Select “Current Location”	Map on screen	Expected result	

Select “Current Location” without selecting “Let’s Cycle Now” first	Google map - Blue screen appears	Expected result	A pop up message would be useful informing the user that needs to select “Let’s Cycle Now “ first
Select “My Routes”	A list with previous routes appears	Expected result	A message would be useful when no previous routes have been recorded
Select “Update My Routes Online”	Progress bar appears followed by a pop up message: Routes were synchronized online”. (SQL Lite and Web site Database are synchronized now)	Expected result. Typo: ~~where~~ → were	
Select “Update My Routes Online” without Internet connection	Warning message appears: “Error – Could not connect to the Internet”	Expected result	
Select a specific route	Map on screen together with the option to share it online	Expected result	
Select “Share Route Online”	Progress bar appears followed by a pop up message: Route was successfully published online”.	Expected result	
Record a route when the Beacon is within the default distance	Route is recorded normally.	Expected result	

Record a route when the Beacon is not within the default distance	Route stops	Expected result	

Table 2: Mobile Application Testing

4.4.2 Web site Testing

To be tested	Expected result	Actual result	Comments
Navigate through the menu	Go to another page or anchors on the home page	Expected result	
Download application from Server	seniorsCycle.apk starts downloading	Expected result	
Enter existing credentials for “My Routes” that has synchronized routes before	A list with synchronized routes appears	Expected result	
Enter non - existing credentials for “My Routes”	“No routes have been synchronized by user: (username)”	Expected result	
Enter existing credentials for “My Routes” that has not synchronized any routes before	“No routes have been synchronized by user: (username)”	Expected result	
Enter existing username for “Community” that has shared routes online	A list with synchronized routes appears	Expected result	

Enter non - existing username for “My Routes”	“No routes have been synchronized by user: (username)”	Expected result	
Enter existing username for “Community” that has not shared routes online yet	“No routes have been synchronized by user: (username)”	Expected result	
Send us a message	Inactive	Expected result	Temporarily unavailable. Required script and use of the SMTP / POP3 mailservers

Table 3: Web Site Testing

5. Conclusions

This chapter includes the original objectives that were met, the positive and negative aspects of the project, the personal learning outcome and some suggested follow – on work.

5.1 Reflections on Aims and Objectives

The **aim and objectives** of this project that were initially planned and stated in this dissertation in Chapter 1 **were essentially all met** and this is **supported by the results of both the Workshop and the Testing process** that are included in the previous chapter.

"SeniorsCycle" is a **fully functional Android application** that **tracks user cycling activity and records related data**, such as Date/Time, distance and average speed on the mobile device. It works in tandem with a **responsive web site** and allows users to **share information online** by **synchronizing the local route information** with the respective **information maintained on the web site**. Finally, the design of the **user interface** is **simple and minimal** to enhance the **usability and accessibility** of the system. A successful **user-trial** was also conducted and **feedback** gathered.

The success of the system's functionality is reflected by the warm welcome and the **acceptance** of the application during the **workshop**. The participants considered the system as **useful** and **easy to operate** and most of them would use it in the near future. It is really important that the system **does not require any previous experience** as most of its functions are self-explanatory. The pop – up messages **inform** the user and the structure of the menu makes the **navigation ideal for a novice user**. The **automated calculation of routes proved rather intelligent and no user complained that the routes which were discovered were in any way differently perceived than the routes that they had actually followed** (in terms of start of route, end of route, places visited). However the study conducted was only **relatively short** and while feedback suggests interest and potential for adoption, **further work** would need to consider further trials.

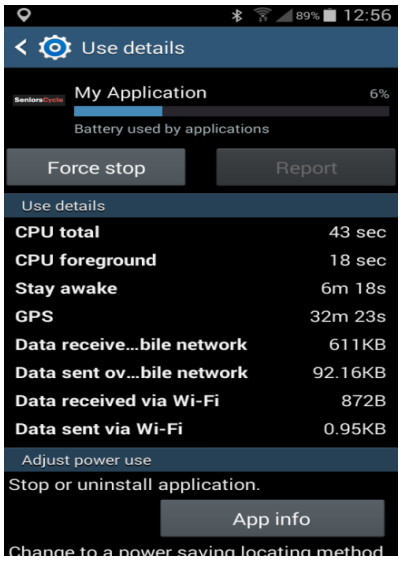
"SeniorsCycle" also **fits in the communication patterns and the motivational factors** studied and it **complies with privacy concerns**, which as **confirmed by feedback**, constitute a very important issue. The users are **not obliged to share their routes online** but only if they wish so. **Other visitors do not have access to their routes unless they are given a valid username.** In addition, **the Beacon substitutes the buttons** and the users only need to enter their username/password, select a Beacon and keep their Bluetooth and GPS on while they cycle.

5.2 Limitations of Design and Study

Therefore, **all the project objectives have been achieved**, but the system without further improvement cannot be considered a commercial product, even though this was never a requirement, but a huge challenge for an ambitious developer. The first reason is obvious; it is developed by a student without any previous experience within less than three months. Regarding the technical part, a basic negative aspect is the lack of features – details and data about the routes, such as speed, elevation, acceleration, that can be used in order to produce a more accurate depiction of the route and define the user's cyclist behavior. In addition, there are some technical limitations that constrict the functionality of the system. For example, if the user turns the Bluetooth off, or decides to ride his bike in a tunnel where there is no GPS reception, then the application will not work properly. Of course, these are all technical challenges that could be easily met in following versions of "SeniorsCycle".

It is worth mentioning though that for the majority of the commercial applications no additional equipment is required. On the contrary, in order to use "SeniorsCycle" the user must purchase an Estimote Beacon. The cost for a pack that contains three Beacons is $99, but Estimote has released a lighter version, the Estimote Stickers that are quite cheaper compared to Beacons ($99 for ten Stickers). The application initially was supposed to be cooperating with the Stickers, but until the beginning of June no SDK was released by the Estimote developers. On the other hand, and this is the strongest point of SeniorsCycle, the use of Beacons and perhaps later Estimote Stickers, increases to a great extend the usability of the application – especially for elderly users, since it minimizes the required user actions on the user interface, so that users may mark the start and the end of each of their journeys.

A important technical limitation of the current system, is the battery consumption. The Android service uses simultaneously the Bluetooth and the GPS, as well as a Wi-Fi / 3G / 4G connection, whenever the user wishes to update his routes online or share a specific route with the members of the community.



Picture 25: Battery usage

Undoubtedly, the biggest disadvantage refers to the fact that the application is not a cross – platform one. It runs exclusively on Android (4.4.1 and newer editions), but is not compatible with iOS and Windows Mobile operating system. During the development and the testing process eight phones in total were used and the application worked as planned. However during the workshop, an attempt to install the application on an old Samsung (deprecated Android version that was never updated) failed and the application terminated. Other participants wished to install the application on their iPhones, but unfortunately that was impossible. This is something that can be fixed in future editions by using PhoneGap or Xamarin and not Android Studio that was used in this case, or Eclipse.

5.3 Personal Skill Development

The reason that Android Studio was used instead of another piece of software that allows multi – platform applications was my intention to practice and develop my Java programming skills by acquiring experience with Android Studio. As a developer I also tried to explore the use and the capabilities of Estimote Beacons and GPS. Another great challenge was the combination of a mobile application with a web site by learning how to effectively design, implement and programmatically consume web services. Also, the web site required an extensive use of HTML, CSS, Javasctipt, PHP and MySQL. In addition, during the development of the project I had the opportunity to do some form of qualitative research for the first time, a collaborative piece of research and conduct a survey in order to evaluate the functionality of the system.

One of the most difficult tasks of this dissertation was to deliver the project on time. Building the app was extremely time-consuming due to lack of experience and the demanding requirements of the project. Therefore, it has been really difficult to accomplish the rest of project's stages, such as planning, designing, testing and evaluating the system and of course documenting every activity. In addition, there are quite a few details that could be implemented, if only there was more time until the final submission.

5.4 Future Development

Nevertheless, newer versions of the system may also include:

- A way to reduce battery consumption.
- A "live" map for the current location.
- A pop up message informing the user that needs to select "Let's Cycle Now" before the "Current Location" option.
- A pop up message informing the user that no previous routes have been recorded if a new user selects to view his routes.
- A check for duplicate accounts.
- Conversion from m/s to km/h or m/h.

- Distribution through Google Play.
- iOS compatibility.
- Screen rotation features.
- Login with Facebook ID.
- A search button so users can find the user whose routes wish to view online.
- Audiovisual content and comments that can be shared with a specific route online.
- Social media to promote the application.
- A contact-form so the users can communicate with the administrator and the developer.

The positive aspects of this project have definitely outweighed the negative ones. It was very interesting exploring a powerful programming language like Java and the utilization of additional elements such as the Beacons, GPS, databases and PHP. Hopefully one day, an updated version of "SeniorsCycle" will be available for commercial use and will encourage more people to start cycling.

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7. Appendices

7.1 Meeting Reports

Meeting 0 - [CSC8099]

Location: Culture Lab, Space 2

Date: 12/5/2015

Time: 15:30

Attendance

John Vines, Konstantinos Papaterpos

Agenda Items

1. Dissertation topic.
2. Use cases.

Action Items

1. Write a brief description of the project.
2. Find similar applications.

Other Notes

Due to limited time the meeting lasted for approximately 25 minutes. Me (Konstantinos Papaterpos) agreed to send a brief description of the project together with a title. John Vines signed me up on NESS.

Next meeting arranged for 1/6/2015.

Meeting 1 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 1/6/2015

Time: 12:30

Attendance

John Vines, Rachel Clarke, Mohammad Othman, Konstantinos Papaterpos

Agenda Items

1. Introduced to Rachel Clarke and Mohammad Othman who will guide me throughout the implementation of the project
2. Changes related to requirements and some aspects of the topic.
3. Use cases.
4. Similar web sites and applications.
5. Estimote Stickers / Beacons.

Action Items

1. Start my literature review.
2. Experiment with the Android Studio environment and estimate stickers.

Other Notes

Instead of a mobile application addressed to senior people that works in tandem with a web site. It and record their daily exercise (walking) data, we agreed that my project would focus on developing an Android application that has the basic functionality to allow people to automate the tracking of cycle journeys in tandem with a Bluetooth Beacon attached to the bike. If feasible in the timescale, I (Konstantinos Papaterpos) could also look at ways of allowing the user to review what has been captured (either on the mobile, or via an associated web page) and publish their routed for others to see.

The use case this will be to support older people learning to cycle, or returning to cycling after many years in order to develop a shared resource of ‘comfortable’ routes and also increasing sociality.

Rachel Clarke and John Vines will be my main point of contact in terms of the overall planning and design aspects of the application, and in helping me to come up with a simple evaluation of the system I build. Mohammad Othman is able to give some support and advice regarding the technical aspects of developing the app, and Gavin Wood will be able to advise me on the Bluetooth Beacons.

Next meeting arranged for 9/6/2015.

Meeting 2 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 9/6/2015

Time: 12:00

Attendance

Rachel Clarke, Gavin Wood, Konstantinos Papaterpos

Agenda Items

1. Introduced to Gavid Wood who will assist with technical difficulties.
2. Replacing Estimote stickers with Estimote Beacons and other alternatives.
3. Quick demonstration of a simple mobile application.
4. Quick demonstration of an early prototype of the web site.
5. Scan for Estimote stickers with BLE apps on both Android and iOS.

Action Items

1. Set milestones.
2. Create Gantt diagram.
3. Continue literature review.
4. Design User Interface.
5. Create MySQL database.
6. Integrate Google Maps API and GPS
7. Write the proposal.
8. Research on how to synchronize the two databases (SQL Lite and MySQL).
9. Research on accelerometer.

Other Notes

During this meeting I (Konstantinos Papaterpos) had the opportunity to demonstrate a simple stopwatch application that I built using Android Studio, together with an early prototype of a web site that will host all the required information.

We considered the possibility of replacing the Estimote stickers with Estimote Beacons, since no SDK for Android has been released yet.

Tomorrow (10/6/2015) me (Konstantinos Papaterpos) and Gavid Wood will meet again and try to connect a Beacon to the Android App and test some of the Beacon's functions.

Next meeting arranged for 16/6/2015.

Meeting 3 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 16/6/2015

Time: 9:00

Attendance

Rachel Clarke, Konstantinos Papaterpos

Agenda Items

1. Editing the project proposal.
2. User Interface.
3. Reducing complexity compared to similar existing mapping apps.
4. Sketches of a fictional scenario.
5. Alternative literature.

Action Items

1. Continue literature review.
2. Create MySQL database.
3. Integrate Google Maps API and GPS
4. Edit and submit the proposal.
5. Research on how to synchronize the two databases (SQL Lite and MySQL).
6. Research on accelerometer.

Other Notes

During this meeting I (Konstantinos Papaterpos) had the opportunity to demonstrate a series of mockup screens that I designed together with the simple stopwatch app that I created and installed on my Android phone.

Rachel Clarke suggested alternative literature that might help and focuses on social media and sketches related to the design and the functionality of the system.

We also spend approximately 30 minutes on editing the project proposal which I (Konstantinos Papaterpos) will email later on today.

Next meeting has not been arranged yet.

Meeting 4 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 22/6/2015

Time: 13:00

Attendance

John Vines, Konstantinos Papaterpos

Agenda Items

1. Update John Vines on recent development.
2. Define the documentation structure.
3. Alternative literature.

Action Items

1. Connect the Estimote Beacons to a dummy Android app.
2. Literature research.

Other Notes

During this meeting I (Konstantinos Papaterpos) had the opportunity to demonstrate to John Vines an early prototype of the web site, a series of mockup screens that I designed together with the simple stopwatch app that I created and installed on my Android phone.

John Vines suggested alternative literature that focuses on

- Social media use among older adults.
- Digital and material social communications for older adults.
- Social networking platform adapted to the needs of elderly users.
- Communication practices of older adults in the digital age.
- How Older Adults Learn to Use Mobile Devices.
- Developing privacy guidelines for social location disclosure applications and services.

We also spend approximately 15 minutes on alternative ways to enable the application and share routes and stats online.

Next meeting arranged for 29/6/2015.

Meeting 5 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 29/6/2015

Time: 13:00

Attendance

John Vines, Rachel Clarke, Konstantinos Papaterpos

Agenda Items

1. Update John Vines and Rachel Clarke on recent development.
2. Conduct a survey and evaluate the system's functionality and reliability.
3. Schedule tasks.

Action Items

1. Find the bug that stops the "activity" that contains the Beacons' list (mobile app).
2. Start designing the User Interface.
3. Background – Technical material part.

Other Notes

During this meeting I (Konstantinos Papaterpos) talked about the recent development of the application and especially about the bug that does not allow the user to view the list with the available Beacons.

Rachel Clarke and John Vines suggested possible solutions related to the survey (eg short interviews with a group of elderly people) and we also scheduled some tasks and set some milestones ahead of my absence.

Next meeting arranged for 6/7/2015 (over Skype).

Meeting 6 - [CSC8099]

Location: Skype

Date: 6/7/2015

Time: 13:00

Attendance

Rachel Clarke, Konstantinos Papaterpos

Agenda Items

1. Demonstration of the stopwatch application.
2. Structure of the Background – Technical material part.
3. Schedule tasks.

Action Items

1. Start designing the User Interface.
2. Finish the Background – Technical material.
3. Design an Android service which will allow the application to run in background.

Other Notes

During this meeting I (Konstantinos Papaterpos) demonstrated an improved version of the stopwatch application to Rachel Clarke. This version allows the user to tap on an option and redirect to a new activity. In addition, the Estimote application is not required anymore to track a Beacon, since the code I wrote can effectively track them. However, there seems to be an issue with the accuracy of the distance but this will be discussed in the near future.

Another issue that is related to the usability of the application is the fact that the user has to start the application manually in order to track a Beacon. A solution that I came up with, includes the design of an Android service. This means that when the Bluetooth is on, the service will start searching for Beacons, and when it finds the correct Beacon (the one that the user has selected the first time he set up the application), it will trigger the application to start.

Next meeting arranged for 20/7/2015 (over Skype).

Meeting 7 - [CSC8099]

Location: Skype

Date: 20/7/2015

Time: 13:00

Attendance

John Vines, Rachel Clarke, Konstantinos Papaterpos

Agenda Items

1. Feedback on the background technical material.
2. Design of the User Interface – Ideas.
3. Evaluation of the application – Survey and testing (workshop).

Action Items

1. Start designing the User Interface.
2. Divide the routes and show them on map.
3. Complete an Android service which will allow the application to run in background.

Other Notes

During this meeting I (Konstantinos Papaterpos) demonstrated an early prototype of the application that allows the user to search for a Beacon, store its mac address or ID into the SQLite Database and retrieve the same Beacon after restarting the app. The user is also able to use the GPS in order to view his current location and store his / her credentials.

An issue that needs to be solved as soon as possible and was discussed during the meeting involves the cyclist's stops during a route. So far, I am able to use the GPS to get the time and distances, but I think that dividing the route into smaller ones, whenever the user is having a break will solve the problem. For example someone might pause his cycling activity for 2 hours (coffee, or lunch break) and then start again. These will be considered as two different routes.

Next meeting arranged for 27/7/2015 (over Skype).

Meeting 8 - [CSC8099]

Location: Skype

Date: 27/7/2015

Time: 13:00

Attendance

Rachel Clarke, Konstantinos Papaterpos

Agenda Items

1. Additional literature on the background technical material.
2. Workshop – Ideas.

Action Items

1. Design the User Interface.
2. Build the web site login function.
3. Divide the routes and show them on map.
4. Design a Web service which will synchronize the user's routes (mobile – web site).

Other Notes

During this meeting I (Konstantinos Papaterpos) sent Rachel Clarke screenshots of the application. At this point the database of the phone is fully functional and routes can now be stored and retrieved.

However, there are two issues that will be discussed during the next meetings:

1. The accurancy of the GPS. For my first route I walked for about a minute but the GPS sent coordinates that were about 10 miles away.
2. Decide whether the route is completed or the user is just taking a break. The only solution sor far for that is to illustrate the daily routes – the user can search by date and say for example that if the Beacon is out range for more than two minutes or the GPS coordinates remain the same for two minutes then we have a completed route. One problem might be if the user decides to ride his bike at 23:55. Then the first minutes will be the last route and the remaining will be the first route of the next day.

Next meeting arranged for 3/8/2015 (over Skype).

Meeting 9 - [CSC8099]

Location: Skype

Date: 3/8/2015

Time: 13:00

Attendance

John Vines, Konstantinos Papaterpos

Agenda Items

1. Completion of the mobile application.
2. Workshop – Ideas.
3. Additional literature review.
4. Server.
5. Domain name.

Action Items

1. Complete the User Interface.
2. Build the web site login function for users.
3. Prepare questionnaires for the workshop.

Other Notes

During this meeting I (Konstantinos Papaterpos) sent John Vines some new screenshots of the application. At this point I have completed the development of the mobile app (show map of routes, filtering inaccurate data -> altitude = 0 etc). However some Google API Key problems still remain.

The Web services are done (it fetches all routes from Server and saves a route on Server from the mobile that doesn't exist on the server), so routes between phone and server are now synchronized.

Currently I am setting up the server and I have purchased a domain name. http://seniorscycle.co.uk.

By the end of this week the web site (login and published routes) will be ready. I need a couple of days for the User Interface in order to make it more accessible and during this weekend I will prepare some questionnaires for the workshop.

Next meeting arranged has not been arranged yet.

Meeting 10 - [CSC8099]

Location: OpenLab, 89 Sandyford Road

Date: 14/8/2015

Time: 15:00

Attendance

Rachel Clarke, Wilbert Den Hoed, Konstantinos Papaterpos

Agenda Items

1. Tomorrow's workshop.
2. Questionnaires.
3. Results - Analysis
4. Equipment.
5. Testing the application

Action Items

1. Find out why three mobiles did not work.

Other Notes

During our final meeting I (Konstantinos Papaterpos) had the chance to demonstrate the application. Unfortunately three HTC mobiles did not record any routes at all.

Rachel Clarke talked about tomorrow's meeting and gave the attendants a full description of the plan.

We agreed on the required equipment and I presented the questionnaires that I will distribute to the participants.

My last task is to find out what prevents three HTC phones from recording routes.

No additional meetings are required.

7.2 Workshop Poster

7.3 Workshop Information

Cycling & Digital Tools Workshop

10am - 1pm
Saturday 15th August
The Cycle Hub
(Quayside, Newcastle Upon Tyne, NE6 1BU)

Thank you for getting in touch about our workshop. We're piloting a mobile phone application that connects people who are new to cycling in Newcastle Upon Tyne. The workshop will be informal and aim to get to know a little bit about you and your cycling history, your interest and use of technology. We will do this by testing a new mobile phone application and website. Here's our plan for the morning.

10 am	**Introductions**
10.30 am	**Mobile application trial with short bike ride**
11.30 am	**Feedback**
12-1pm	**Final comments and lunch**

If you have any further questions please get in touch with Rachel, who will be leading the workshop.
T: 07841584922
E: rachel.clarke@ncl.ac.uk

Web: www.myplace.ac.uk

Twitter: @myplace_ncl

Facebook: MyPlace Newcastle

MyPlace

Open Lab at Newcastle University

northumbria UNIVERSITY NEWCASTLE

EPSRC Engineering and Physical Sciences Research Council

Lifelong Health & Wellbeing

7.4 Participants' Details

MyPlace

SeniorsCycle – user-testing 15th Aug 2015 10am-1pm

The Cycle Hub, Quayside, Newcastle Upon Tyne, NE6 1BU

Information collected on forms

M/F	Age	Medical Conditions	Access Requirements	How did you hear about the workshop	Length of time cycling	Travel to workshop	Description of technology use on an average day	Use of technology for cycling
F	59	Lyphodemia in legs	No	Yvette from Hub	5 weeks	Car	None	None
F	54	Anxiety – under control	No	Weigh Weight – This Gil Can	6 weeks	Car (lift)	iPad – to check emails, research and games. iPhone – text and call – only have as inherited son's. Don't have apps – only what son downloaded	Google
M	65	Epilepsy – no attack since 1990	No	From a friend	5 years	Bike		
F	67	No	No	Met Liz Jackson on 1st Aid at work course and she sent me info via email	Rode a lot as a child, recently 1996 – 2000 at least 10K a day – now nothing!!	Car	Work in sixth form in Gateshead school use word processing and excel. Use Smartphone – badly!!	Internet and email
F	54	No Thyroid –	None	Liz Jackson,	6 weeks	Car	iPad mini – browsing	Yes – Endomondo Strava

		take Levothyroxine for life. Depression – no medication		Cycling in City Co-Ordinator			internet, blogs, newspaper, connecting with family via Skype. Facetime. Jawbone up – fitness tracker Garmin – for running and cycling iPhone – telephone calls, calendar, internet	Jawbone Up
F	54	No	No	Liz Jackson, Cycling and Walking Officer for Newcastle	Just over 1 year	Bike	iPhone, iPad and laptop, but I struggle my way around. I can still pick up if someone shows me how things work.	Yes I use Map My Ride and Goskyride
F	63	Joint pain	None	Liz	3 weeks	Retired (maybe bus)	Mobile phone	No
F	56	No	No	Email from Liz Jackson Cycling and walking officer	Not cycled for about 12 mths	Car	Internet and email, don't really use technology. Use a pedometer for walking.	Internet. Don't really track my activity
F	58	Diabetic	No	Facebook	Haven't cycled for a long time.	Bus and walking	N/A	No
F	57	Ashma	N/A	Yvette	Never been on a bike since I was 11 years old so I am just starting off.	Car	Mobile phone	No
F-90% M-10%	M 58.7							

7.5 Questionnaire

Workshop - Questionnaire

Section A

1. Do you own a smartphone?

Yes ☐ No ☐

1b. If yes, have you installed any applications on your phone?

Yes ☐ No ☐

2. Do you have internet at home?

Yes ☐ No ☐

3. Do you use internet on your phone to browse the web?

Yes ☐ No ☐

4. Have you been registered to any of the social media (eg Facebook, Twitter, Instagram etc)?

Yes ☐ No ☐

5. Do you use frequently the GPS function for navigation?

Yes ☐ No ☐

Section B

1. How useful do you think "SeniorsCycle" is?
   Extremely ☐ Very ☐ Useful ☐ Not ☐ Not at all ☐

2. How difficult do you think it was to use?
   Extremely ☐ Very ☐ Difficult ☐ Not ☐ Not at all ☐

3. How likely is to use "SeniorsCycle" again?
   Extremely ☐ Very ☐ Likely ☐ Not ☐ Not at all ☐

4. How easy was to set up the application before using it?
   Extremely ☐ Very ☐ Easy ☐ Not ☐ Not at all ☐

5. How helpful was the design of the application?
   Extremely ☐ Very ☐ Helpful ☐ Not ☐ Not at all ☐

Section C

1. Which function do you think was more useful?

(Please select one)

A. Current location ☐
B. Map of routes ☐
C. Statistics related to routes ☐
D. Share routes with other people ☐

2. Would you prefer a start button or a Beacon to start the application?

(Please select one)

A. Button ☐
B. Beacon ☐

3. Would you prefer additional buttons on screen or the integrated buttons of the phone?

(Please select one)

A. Additional buttons ☐
B. Integrated buttons ☐

Section D

Please tell us some things about your experience (50 – 150 words)

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