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A Noticeboard application using context aware services

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A Noticeboard Application Using Context Aware Services

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Declaration and Approval

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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Approval

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Dedication

I dedicate this dissertation to God, my family and friends who have consistently encouraged me throughout the entire process, my classmates for their hard work, dedication and support, the instructors who took their time to show me the way, the open source community for providing the tools required to complete this research and my supervisor Dr. Shibwabo, who guided me through to the end of this research.

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Abstract

The dissemination of information on campuses using noticeboards is both inefficient and ineffective due to the static, unreliable and limiting nature of the boards. This implies that people who need to post information for consumption by the public are constrained in terms of reach, poor feedback mechanisms and a general lack of security. Posts can be tampered with by malicious people or even removed by competitors. Due to their fixed nature, noticeboards also do not cater for context, meaning that a lot of posts are consumed outside of their actionable spaces, meaning that people might never get a chance to act on them.

There is therefore a need for a smart noticeboard system using the power of context aware services that allows for notices to be sent directly to user's devices only when they are in the correct context. The aim of this research is to develop a noticeboard application that uses the power of context aware services. With such a solution, students are able to receive notices through an application when they are in the correct and most effective context and be in a better position to react or act on them accordingly. They are also able to save notifications on their mobile devices for later use or sharing. The solution therefore supports the communications departments by providing an easy, paperless way to setup notices and to track interactions with each post.

The proposed system is developed and tested on the Android platform coupled with an analytical backend for post manipulation and presenting summaries analytical data for the communication department. Object Oriented Analysis and Agile development methodologies were applied to develop a robust and dynamic, context aware noticeboard system. The final prototype was tested to ensure that the requirements were met by the developer and the potential users. Tests included functional testing and usability testing.

Keywords: Noticeboards, Context Aware Services, Information Disseminate, Android.

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List of Abbreviations

BLE	- Bluetooth Low Energy
SU	- Strathmore University
UI	- User Interface
GUI	- Graphical User Interface
CoBrA	- Context Broker Architecture
Wi-Fi	- Wireless Fidelity
GPS	- Global Positioning System
UUID	- Universally Unique Identifier
IOS	- iPhone Operating System
UML	- Universal Modelling Language
ERD	- Entity Relationship Diagram
SDK	- Standard Development Kit
SQL	- Structured Query Language
ID	- Identity Document

Chapter 1 : Introduction

1.1 Background

Communication is by far one of the most distinctive traits of the human species (Adler & Rodman, 2006; Fiske, 2011; Richmond & McCroskey, 1995). The ability to pass varying information along from one person to the next sets us apart in the animal kingdom using both verbal and nonverbal means (Hub Pages, 2015; Johnson, 2015). Without our ability to communicate, life would be far much harder than it is right now (Fluency Translation, 2014). Communication however needs to be achieved efficiently and effectively.

Communication forms the backbone of every institution of learning, with the entirety of the learning process being hinged on its effectiveness (Escudar & Esteller, 2009; Kowalski, 2007). Lectures, textbooks, the Internet, electronic media and notices are the main source of learning and acquiring information in these institutions (Escudar & Esteller, 2009; Spielgaben, 2013). Outside of the communication that happens during formal education, there are a lot of messages that are passed along, supporting the whole process. Most of these messages are passed along either verbally through one on one interactions, electronically through emails and website postings or most importantly on noticeboards and bulletin boards (Biczysko, 2013).

The noticeboard is an important part of formal education, helping educate children in primary and secondary schools and to inform people in colleges and universities (Early Learning Future, 2015). For the children, teachers have used bulletin boards to post science projects, display creativity through posting artwork and poetry as well as posting inspiration for the children to look up to (EducationWorld, 2006; Ramani, 2011). In the colleges and universities varying information about campus activities are posted, ranging from career opportunities to tuition programs and importance health and safety notices (Ashburton, 2016; Dawson , 2016).

With the arrival of smartphones, the conversations on campus have moved from emails and noticeboards to social media (Brown, 2015; Kim, 2015; Pitsburg State University, 2013). People share important information through social media platforms like Facebook, Twitter and WhatsApp, forming groups within which relevant information can be shared. According to Carahar (2010), students have been observed to use social media to connect with classmates, work

on assignments and in some instances connect with their faculty. The rise of social media puts the traditional noticeboard in danger of going extinct, with most things moving online and very few people taking time to go through information that is placed on these boards.

Despite the shift to more digital and paperless means of passing messages and notifications along, it is important to note that the noticeboard is still an integral part of campus communication (Bernard, 2015; Ramani, 2011). In the case of Strathmore University, despite the slow update times, location and space issues, noticeboards still play an important role in communication due to their visual nature. Evolving the noticeboard through context aware services, smartphones and their applications is one of the ways to make the board more relevant and up to date.

The discussion of how and when information is delivered to people in different contexts is becoming more and more important with information overload being seen as a growing problem (Horrigan, 2016; Ross, 2014; Zanarini, 2017). People are being bombarded with information on their various smart devices through multiple sources such as email, text messages, phone calls, social media sites, adverts, videos and many more (Horrigan, 2016). We are exposed to information worth 175 newspapers on a daily basis, making it harder and harder to focus on what is important to us. This inability to sift through what is important on the Internet and what is not is posing a major challenge.

With more powerful and more capable smartphones coming out every year, the shift to ubiquitous computing is becoming more and more a reality (Krumm, 2009; Rouse, 2016). Without context awareness, smartphones are pretty much blind and deaf, not knowing where they are and the things that are happening around them (Chen, 2004; Schillit, 1994). This lack of context renders it useless in providing helpful information to its user, in environments where context aware services are running or required.

1.2 Problem Statement

The main problem with the traditional noticeboard (bulletin board) is that it is static, unreliable, inefficient and limiting to the people who want to put up notices and their intended audiences (Bernard, 2015; Carreon, 2013; Dawson , 2016; Ramani, 2011). It does not cater for the needs of all the notices in terms of context, meaning that messages of all kinds are presented to the consumer outside of the correct context, essentially reducing their effectiveness and action ability (Collet,

2016). Without these notices being presented in the correct context, consumers do not have a chance to immediately interact with them or react to them without leaving the notice area.

In most academic institutions there are a limited number of places to place noticeboards, most of which are located in public spaces (Bernard, 2015; Ramani, 2011). This ease of access is both an advantage and a disadvantage, the latter being that anyone can place a notice or make comments, relevant or otherwise (Carreon, 2013; Early Learning Future, 2015). It is also hard to gauge just how effective a notice has been in carrying out its intended purpose due to the fact that there are no immediate ways of the audience reacting to it or for the notice poster to monitor user traffic (Bernard, 2015).

There is need to develop a mobile solution which will leverage the power of context aware services to deliver notices and advertisement in the correct and most actionable context. This application would fill the information gap left by the traditional noticeboard and other communication channels used in communication on campuses.

1.3 Research Aim

The aim of this research is to develop and test a smart noticeboard mobile application which leverages the power of context aware services using Bluetooth Low Energy (BLE) Beacons to deliver information to users only when they are in the correct context.

1.4 Research Objectives

    I.   To investigate the factors leading to poor information dissemination on campuses.

    II.   To analyse current techniques and technologies used in context aware services

    III.   To develop and test a platform that support information dissemination on mobile devices through the power of context aware services.

    IV.   To validate that the developed context aware noticeboard application so as to confirm that it provides proper context aware notices that are relevant to student needs.

1.5 Research Questions

The study sets out to provide answers for the following questions:

    I.   Which are the factors leading to poor information dissemination on campuses?

    II.   What are the current techniques and technologies used in context aware services?

    III.   How can a context aware noticeboard application be designed, developed and tested to disseminate information to users?

    IV.   Does the application provide proper context aware notices relevant to student needs?

1.6 Justification

In order to ensure that information dissemination on campuses is made more effective and efficient, with students receiving relevant notices only when they are in the correct and most actionable context, there is a need to create more context ready environments and information systems (Collet, 2016; Cristea, 2013). Providing a uniform system for information dissemination using the power of the smart phone and context aware services will ensure that information on campuses is received only when most relevant, essentially increasing the effectiveness of the notices.

Using a mobile application to disseminate information on campuses using context aware services will be efficient, effective fast and affordable. This is because of the high adoption and ease of access to smart phones in Kenya and especially among the youth, most of whom are technology-trend aware (Ekwealor, 2016; ITNewsAfrica, 2014; Kemibaro, 2016; Zab, 2015). This study aims to come up with a mobile application which uses the power of Bluetooth Low Energy (BLE) and context aware services in information dissemination on campuses.

1.7 Scope of the Research

This study offers a prototype and not a complete application with the data used being test data, modelled around the systems currently in place at Strathmore University (SU), with the aim of later integrating with main existing systems and using actual student data. The final product allows users to access information and data from beacons placed at specific places within campus, enabling them to interact with the information and act on it. Students are able to access notifications across campus on their mobile phones.

1.8 Limitations of the Research

There are certain limitations that are associated with building a noticeboard application which uses the power of context aware services. These limitations include all users in need to access the services are required to install the application on their mobile devices. The supported mobile devices are smart phones running Android 4.0 and above, which have Bluetooth low energy enabled on their devices.

Chapter 2 : Literature Review

2.1 Overview

With fast and consistent rise of technology in the mobile sector in Kenya, it is only a matter of time before people become fully mobile dependent (Alleyne, 2011; Rosen, 2015; Shukla, 2010). With more than 7.1 billion active mobile devices in the world, it is easy to see just how quickly and aggressively the mobile sector is growing, there being more mobile phones in the world than there are people (Boren, 2014; Fox, 2015; Mobile Future, 2016). In Kenya alone there are more than 32 million active mobile devices and 1.8 million smartphones, most of which are in the Nairobi (Kemibaro, 2016; Nation, 2016; Tech Point, 2016; Zab, 2015). The youth are the leading smart device holders in the country, most of them using their devices to access the Internet and social media features.

In campuses, smartphones have become the cornerstone of an ever growing student-teacher-campus interaction cycle (Chronical, 2011). More and more universities have social media accounts through which they interact with their students and faculty, easing the communication burden that there was before (Biczysko, 2013; Cannon, 2015; Patterson, 2016). Students use their smart devices to enhance their learning experience, sharing directly with other students and faculty. The rise in smartphone adoption has been heralded by many as being a good thing, but also a bad thing, especially for students (Barnwell, 2016; College Degrees, 2011). Teachers have been frustrated by student's texting, tweeting and snapchatting in classrooms, effectively reducing productivity and effectiveness of their trainers (College Degrees, 2011; Matchan, 2015). Despite this, many still say that smartphones can and should be used more effectively to support the learning process on campuses.

One of the ways of using smartphones to enhance student learning and the overall campus experience is through the use of context aware services delivered via Bluetooth low energy beacons (Biczysko, 2013; Beelieve, n.d.). Providing information and services to students when they require them and can act on them is of high importance. This chapter looks at the challenges faced by institutions of higher learning in disseminating campus related information to students and faculty. It also looks at some of the techniques and technologies that can be used to achieve context awareness.

2.2 Factors Leading to Poor Information Dissemination on Campuses

There are many challenges faced in information dissemination on campuses (Rampersad, 2010; Waddington, 2010). According to Waddington (2010), these challenges are brought about by two main factors which are: the channels used in communication and the effectiveness of the messages being passed along through these channels. Anyangwe (2012) supports this by noting that organization with poor communication structures are more likely to have performance issues than those with effective, well-structured systems. This section investigates two main factors causing poor information in institutions of higher learning.

2.2.1 Channels Used in Communication

Communication on campuses has evolved over the years to accommodate new trends and the ever changing technological landscape surrounding the entire education process (Carnevale, 2006; Lodge, 2010). Communication channels have been forced to adapt to the modern day tech-savvy students who are in possession of smart devices that allow for instant communication between them and their peers, families and friends (Chronical, 2011). Lodge (2010) notes that the communication process has now been overrun by other faster, more effective communication channels with the main ones being:

I.   Email
II.   Noticeboards
III.   Websites and social media

2.2.1.1 Email

Email is today the primary means of communication between the administration and the students and faculty (Lodge, 2010; Hassini, 2006). It has taken up this role due to its effective nature, speed of delivery, extensive reach ease of use and accessibility and its formal and official nature. Despite it being the most formal and efficient means of communication between campus administrators and students, it still falls short because learners from across the world regardless of their disciplines still choose to ignore campus emails (Carnevale, 2006; EAB, 2016; Mangan, 2012; Straumsheim, 2016). A survey done by Hargittai (2008) at the North-western university found that students often ignore messages coming from their universities because they considered them to be spam due to the large volume of information that can be sent through the medium, a lot of which is irrelevant for a lot of the people receiving them.

Students across the world have developed a certain disdain for campus mail meaning that they end up missing important information on deadlines, class cancellations and events (Carnevale, 2006; Mangan, 2012; Straumsheim, 2016). Some institutions of learning have tried to move away from the more formal systems to the more student friendly platforms such as messaging apps but this transition has proven to be slow in adoption. Dealing with this problem requires a solution which cuts across the divide in order to reach students more effectively.

According to Kim (2015), the reason why internal communication via email has become so difficult is because of the following reasons:

I. **Message Saturation and overloading**: there are already too many messages being sent using this channel meaning that the influx of communication greatly outweighs the demand for the communication (Kim, 2015). It also does not help that email has become the primary source for most communications which means that everyone is emailing about different things, leaving the recipient with the task of sifting through what is important and what is not.

II. **Poor email design**: Due to the saturation and overloading of emails in this day and age, a lot of people will not go through the trouble of reading an email if it is poorly designed and is not appealing to them (Kim, 2015). The email recipient after sifting through all the emails and choosing the most relevant and important ones to them are still very likely to miss out on the intended message that they were supposed to receive do to the structure of the email.

2.2.1.2 Noticeboards

The noticeboard is one of the oldest means of campus communication alongside the traditional posted letter (Carreon, 2013). They play an integral role in the learning processes by providing a fixed means of communication. There are noticeboards spread out across campuses in the different schools, which are meant to be used to pin up relevant information for students, faculty and visitors (Ashburton, 2016; Bernard, 2015). These noticeboards are accessible to students and staff, as well as external parties looking to conduct publicity campaigns within campus.

Communication via these boards is however not the most effective due to a number of factors including board location and their overall static nature, the possibility of message distortion and removal by malicious people and limitations in space (Dawson, 2016). Due to these factors,

learners rarely get a chance to interact with them meaning that messages might go unseen by the intended audiences.

2.2.1.3 Websites and Social Media

For most institutions of higher education, the website is one of the primary means of communication with the external world (Hargittai, 2008; University of Kentucky, n.d.). These web platforms also support communication via email as well as the possibility of intranets supporting different functions. The average campus website hosts information on enrolment and admission, newsletters, information on different schools and their faculty as well as well as student and campus life information (Lodge, 2010; New, 2015). The main problem with the website is that it is not updated as quickly as other means of communication can be, is difficult to develop and maintain with the costs being quite high (Myers, 2015). This limits the kind of content that can be placed on the website to information that does not change too often. Kim (2015) also notes that people very rarely visit websites and when they do, they go there for specific information, very rarely taking time to look through the rest of the content.

Social media on the other hand has taken over as the primary source of information for people across the world (Anderson, 2014; Coleman, 2013; ECO International, 2016; Wakefield, 2016). Facebook leads the way as one of the main sources of news outside the official news websites, with more than 64% of Americans using the social media platform actively and 34% of the population using the site as their primary news source (Anderson, 2014). For institutions of learning, it has become imperative to have social media accounts for university and student interactions due to its wide reach and use amongst student and faculty populations (Biczysko, 2013; Gupta, 2015; I-Student, 2015; Subramanyan, 2013).

Despite its spread, it is not the most effective channel to reach students due to the sheer amount of information that goes onto the platform (Diab, 2013; Social Samosa, 2016). People are bombarded with content and advertisements from multiple sources on the platform, making it really hard to make important content stand out (Ellen, 2016; Peterson, 2016; Ross, 2014). Outside of this, Constine (2016) explains in an article that social media sites like Facebook also employ algorithms that try to limit the amount of content sources one can view content from. For example, if a student rarely interacts with the university social media pages, the algorithm relegates posts from this site

to the bottom of the pile which means the student will probably never get to see the post not unless they visit the site directly (Constine, 2016).

2.2.2 Message Effectiveness

How effective a message being passed along can determine whether or not the message will be understood or even read by its intended recipients (Waddington, 2010). Considering that we live in a time where information access is easy and information overloads are the norm, it is imperative that messages of any kind of importance be structured in the most effective manner in order to pull and keep the attention of its intended audience. According to ASEP (2008), communication between parties break down for the following reasons:

I.   Messages are not direct: this means that messages that are not straight forward and straight to the point may often be misunderstood, distorted, misinterpreted or even ignored. ASEP (2008) notes the reason for this is that the recipients may not know the stand that the message is taking and may end up interpreting the messages in a way not intended by its sender.

II. Messages sometimes lack ownership: In a lot of cases, corporates send out messages that have no identity. This means that these messages have no human elements to them and are often considered to be spam by the recipients. ASEP (2008) points out that messages that have identity, i.e. a message from Brian from accounting, is more effective than a message from 'the Team'.

III. Messages are not complete and specific: Most messages sent out do not tell the whole story, leaving out important pieces of information that could be vital to how the reader responds to the message.

IV. Messages are not clear and consistent: Messages that keep changing with every new mail end up sending mixed messages which show that the sender is undecided and unsure of themselves. Sending out messages that are consistent every time could be the difference between the intended audience reading the message or ignoring it completely.

2.3 Techniques and Technologies Used in Context Aware Information Dissemination

The main challenge that presents itself as a result of distributed computing is coming up with applications that are aware of the context within which they operate (Collet, 2016; Vlachostergiou, 2014). Such systems would have the ability to mutate according to the location that they are in, the devices around it, hosts, people and the changes that occur to things over time (Dey, 2001; Jones, 2017; Schillit, 1994). An application built with such capabilities would be able to get information from its environment, look for changes in the environment and react to them accordingly.

2.3.1 Defining Context and Context Aware Computing

There are many different definitions of context that have been put forth due to the diverse and rich nature of the topic itself. Context was first defined by Schillit (1994) as being location, identities of nearby people and objects, and changes to those objects. The dictionary definition of the term context is the set of circumstances or facts that surround a particular event, situation etc. (Collins English Dictionary, 2012). The definition that we are going to use in this paper however was put forth by Dey (2001), where he defines context as any information that can be used to characterize the situation of an entity.

Context aware computing on the other hand can be defined as giving an application or a system the ability to get relevant information about its environment in an effort to help the user complete a task (Dey, 2001). According to Pascoe (1997), there are 4 features that a system must have in order to be considered to have context aware capabilities. These are:

I. Contextual sensing - ability to sense/ detect contextual information and present it to the user.

II. Contextual Adaptation- The ability to execute or change a service automatically depending on the context

III. Contextual Resource Discovery- this allows an application to find and exploit resources that are relevant to the users context

IV. Context Augmentation- Ability to associate digital data to a user's context. For example, if a user is using a certain machine in a laboratory, they can leave a virtual note for any other users to view when they are in the context of the machine in question

2.3.2 Categories of Context Aware Applications

There are 4 categories of context aware applications as stated by Schillit (1994). These are:

    I.   Proximate Selection

    II.   Automatic Context Reconfiguration

    III.   Context Information and Commands

    IV.   Context Triggered Actions

2.3.2.1 Proximate Selection

Proximate selection is a UI technique that emphasizes the located-objects that are nearer to the user more than those that are further away (Moran & Dourish, 2009; Schillit, 1994). This means that the detectable objects that are closest to the user are considered to be of a higher priority and are either displayed first or made easier to select as compared to the others as shown in Figure 2.1.

(a)

Name	Room	Distance
caps	35-2200	200ft
claudia	35-2108	30ft
perfector	35-2301	20ft
snoball	35-2103	100ft

(b)

Distance	Name	Room
20ft	perfector	35-2301
30ft	claudia	35-2108
100ft	snoball	35-2103
200ft	caps	35-2200

(c)

Name	Room	Distance
caps	35-2200	200ft
claudia	**35-2108**	**30ft**
perfector	**35-2301**	**20ft**
snoball	35-2103	100ft

(d)

Name	Room	Distance
caps	35-2200	200ft
claudia	35-2108	30ft
perfector	35-2301	20ft
snoball	35-2103	100ft

Figure 2.1: UI Techniques for Proximity Selection (Adapted from Schillit, 1994)

This technique is mostly used on at least three different types of located objects in an environment the first being computer input and output devices that require co-location for use (Chen, 2004; Dey, 2001; Schillit, 1994). This includes printers, monitors, and cameras and so on. The second involves things that the user is already in contact with and require interfacing through software. A good example would be interacting with a person who is in the same room as the user and requires the user to Bluetooth them a file. The third category of located objects includes places that a user

would like to discover when they are out and about in the city. These include restaurants, night clubs, and theatres and so on. A good example of this would be to think of it as an address book that sorts locations out based on their proximity to the user in question (Chen, 2004).

As depicted in Figure 2.1, section (a) shows how location data can be used to identify printers within the location of the used. The idea here is to display the closest printer to the user regardless of the order in which they are arranged. If it is done alphabetically like in sections (c) and (d) on the diagram, emphasis techniques like making the closest ones bold or making the closest ones larger than the rest can be used.

2.3.2.2 Automatic Contextual Reconfiguration

Reconfiguration is the process of adding and removing new components as well as altering connections between components (Dey, 2001; Moran & Dourish, 2009; Schillit, 1994). When a group of people are in a room, sharing resources is made relatively easy, for example a table or a chalk board. To replicate this scenario on a tablet, Schillit (1994) created a program that equally allocated resources to users the moment they were in that vicinity. When users walked into a room, their mobile devices were immediately bound to a virtual white board, making it easy for all the participants in the room to be able to collaborate with ease. Leaving the room and entering another would automatically do the same, allocating whatever virtual resources that were available to the users.

Location is not the only kind of context information that can be used in automatic reconfiguration however (Chen, 2004; Vlachostergiou, 2014). Factors like participants could also act as context information. If all the members in a meeting room belong to a specific planning team, resources related to the planning process can be allocated to them as necessary. Persistence can also be introduced in the same case, where the planning team uses a white board for their first meeting and use it again for the second meeting. Some of the material written on the board should not be erased depending on the group requirements as they may be useful for subsequent meetings. There are constraints faced using Automatic Contextual Reconfiguration which are similar to ones faced in reconfiguring systems in general. Things like rapid context change could be confusing for the user as well as confusion brought about by incorrect or slow reporting of location information.

2.3.2.3 Contextual Information and Commands

Peoples actions can often be predicted by the situation/ contexts that they are in. There are certain things that people are known to do when they are in the kitchen or at the office that can be patterned out and used as context information. Contextual Information and Commands exploits this fact (Dey, 2001; Pascoe, 1997). Queries on context information can produce different results in different contexts. In the same way, parametrization can be done on context commands, a good example being that of the print command. Whenever it is initiated, the default setting can cause it to always print to the closest device to the used.

2.3.2.4 Context Triggered Actions

Dey (2001) describes Context Triggered Actions as being similar to If then Else statements in their execution. This means that an application will wait to receive context information from its environment before adapting. This can be used to execute contextual reminders of date and times related to certain events. The user for example can setup a reminder for coffee whenever they are near the kitchen within certain times and dates. It however goes beyond just time and date reminders, giving the user the ability to give more specific context based information. An application can in this case be setup to remind the user of specific information like "remind me to call Mike".

2.4 Overview of Context Aware Features

For an application to be considered to be context aware, it must have the following features and components:

2.4.1 Mobile device characteristics

According to Omwenga (2016), in the development process factors like screen size, processing power, operating systems, and mobile device type are some of the characteristics that must be put into account. Benou and Bitos (2008) note that mobile devices are limited by small screens, low processing power and limited memory. They also point out that during application design and development, aspects of design and performance of the device be put into consideration.

2.4.2 Mobile application development platforms and operating platform

The development platform is a key factor to be put into consideration during the application development process. According to Omwenga (2016) some of the most used platforms include

IOS, Flash Lite and Java ME amongst others. He notes that the difference in development platforms affect portability, functionality, development speed and performance in different ways. Unhelkar and Murugesan (2010) and Dehlinger and Dixon (2011) also point out that the operating system running on the device also affects the mobile application development process.

2.4.3 Nature of content and service deliver

Omwenga (2016) notes that the type of content and service delivery is an adaptive functionality component that encompasses aspects of usability and user experience like font size, aesthetic values, formatting of data, the mobile application graphical user interface and identifying with core user stories or feedback (Omwenga, 2016). These features influence the usability and adoptability of the mobile application from the user perspective. He further notes that how data and content is formatted is the most important aspect of service delivery in mobile application development.

2.4.4 Changes in the mobile environment

As noted by Omwenga (2016), where an application is developed for determines what kind of content comes from the user. This means that this difference in locale affects the development process directly, with different locations requiring different content and service delivery.

2.4.5 Cellular network capabilities

Cellular network capabilities are both a functional factor and a core application logic factor in the mobile application development process (Omwenga, 2016). The performance of a cellular network at a location directly affects the mobile application performance. The ability to pull data off a server without hindrances is key to the functionality of a context aware mobile application.

2.4.6 Mobile Security Considerations

With the ever growing risk of insecurity on mobile devices, it is critical to ensure the security of user devices while using context aware services (Omwenga, 2016). Omwenga (2016) notes that it is imperative to apply security measures at multiple stages of development including at the user level, over cellular communication networks and at the host computers that are sued to run the mobile applications. Authentication, cryptography, secure communication, and secure mobile payment methods can be used to provide the much needed security in mobile applications.

2.4.7 Human and Mobile Device Interaction

Human aspects like preferences, knowledge and attitudes are direct determinants of the possible user expectations on the kind of mobile application that should be adopted (Omwenga, 2016). This interaction between the human and the mobile device determines many aspects that affect the user experience and overall usability of the mobile application.

2.4.8 Mobile Application Performance

While developing for context aware services, how well the mobile application performs is key to the whole experience. Speed of the cellular network the mobile device is tethered to, mobile device performance and computational power of host devices directly influences the mobile application performance.

2.4.9 Application consistency across mobile devices and operating platforms

Benou and Bitos (2008) note that the same mobile application should work across different mobile platforms and devices, offering some consistency in usage by meeting the functional and interface needs of these devices. This consistency is affected directly by the mobile application development platform and the technologies surrounding the entire process.

2.5 Overview of Context Aware Frameworks

This section briefly looks into some of the common Context Aware Frameworks currently in use comparing and contrasting them. According to Lee (2006) these include:

    I.   Context Broker Architecture (CoBrA)
   II.   Context Management Framework
  III.   Gaia
  IV.   Context Toolkit

2.5.1 Context Broker Architecture (CoBrA)

Chen (2004) describes CoBrA as a broker-centric agent architecture used to support context aware computing in smart or intellingent spaces. As shown in Figure 2.2, a broker maintains and manages a shared context model on behalf of a community of devices, provide necessary services and support as well as enforcement of security and provacy policies. The broker in this case is said to have 4 main functions:

I.   Acquisition of situational information from multiple, differing sources.

II.   To interpret the context information and to reason about context in an intelligent space

III. Help distributed agents share contextual knowledge

IV.   Protect the privacy of users

V.   To facilitate collaboration between agents

VI.   Maintain context knowledge on behalf of resource poor agents and devices.
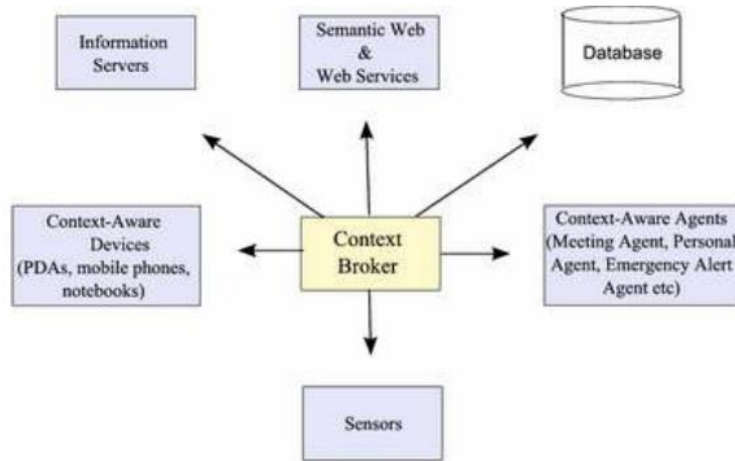
Figure 2.2: CoBrA Architecture (Adapted from Chen, 2004)

2.5.2 Context Management Framework

The context management framework is a good example of the Blackboard architectural design. It consists of several entities including context manager, resource servers, context recognition services, change detection server, security component and an application (Chen, 2004; Lee, 2006). Figure 2.3 shows how the framework is structured.
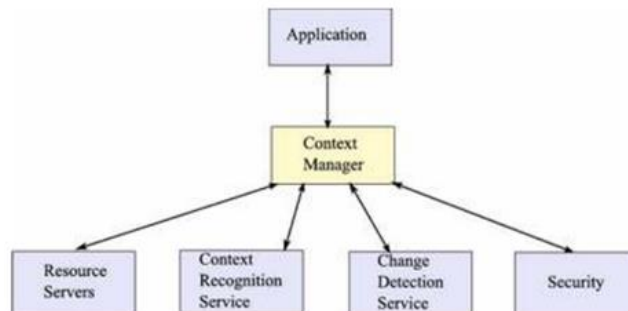
Figure 2.3: Context Management Framework (Adapted from Lee, 2006)

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The context manager sits in the middle of this whole setup, receiving and interpreting information from multiple sources and delivering it to the correct applications and processes. Data acquisition is performed by the resource servers, while the context recognition services are used on demand by the context manager to deduce complex data out of simple context entities (Chen, 2004).

2.5.3 Gaia

Romero (2008) describes Gaia as a distributed context aware Middleware that has simmilar functionalities as an operating system would, ideally coordinating multple software entities and networked heterogeous devices in active spaces. Gaia exports services to query and use existing resources, to utilize current context information, and it provides a framework to develop user-centric, resource-aware, multi-device, context-sensitive and mobile applications (Baldauf, 2007; Lee, 2006). Figure 2.4 shows the Gaia Architecture and the Gaia Kernel
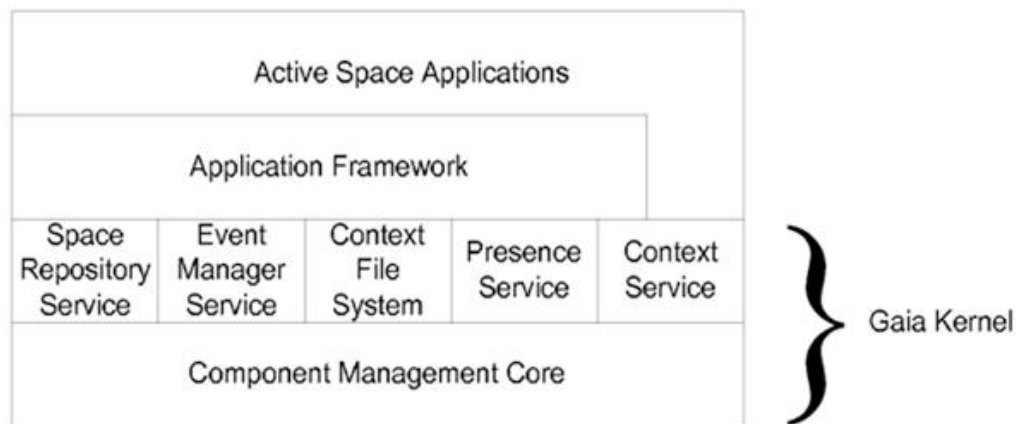

Figure 2.4: Architecture of Gaia System (Adapted from Baldauf, 2007)

2.5.4 Context Toolkit

Dey (2001) describes a context toolkit as a tool that enables developers to build context aware applications with ease. It utilizes the widget architecture and makes life easier for developers by providing a common framework for them to build on. It consists of 3 main abstractions:

I.   **Widgets:** in the same way that a GUI widget works as a bridge between the user and the application, the context aware widget acts as the bridge between the user and their environment.

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II. **Aggregators:** can be thought of as meta-widgets, taking on all the capabilities of widgets plus the ability to aggregate context information of real world entities like people or places.

III. **Interpreters:** these are used to interpret lower level context information into higher level information. For example, location, identity and sound information from a room should be interpretted as room occupancy.

2.5.5 Comparison of Frameworks

Baldauf (2007) makes a comparison of all of the above mentioned frameworks against a set of common criteria like Architecture, Sensing, Context Model Resource discovery, Storage of historical data, security and privacy and Context Processing as shown in Figure 2.5.

Architecture	Sensing	Context model	Context processing	Resource discovery	Historical context data	Security and privacy	
CoBra	Agent based	Context acquisition module	Ontologies (OWL)	Inference engine and knowledge base	n.a.	Available	Rei policy language
Context Management Framework	Blackboard based	Resource servers	Ontologies (RDF)	Context recognition service	Resource servers + subscription mechanism	n.a.	n.a.
Context Toolkit	Widget based	Context widgets	Attribute-value tuples	Context interpretation and aggregation	Discoverer component	Available	Context ownership
Gaia	MVC (extended)	Context providers	4-ary predicates (DAML + OIL)	Context-service module (first-order logic)	Discovery service	Available	Supported (e.g., secure tracking, location privacy, access control)

Figure 2.5: Comparison of Context Aware Frameworks (Adapted from Baldauf, 2007)

2.6 Technologies Used in Achieving Context Aware Computing

There are a number of ways to achieve context awareness using smart mobile devices. The three main methods that are currently being used include:

I. Context awareness using Global Positioning System (GPS)

II. Context awareness using Wireless Fidelity (WiFi)

III. Context awareness using Bluetooth Low Energy (BLE) Beacons

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2.6.1 Context Awareness Using GPS

Global Positioning System (GPS) is satellite based navigation system developed in the 1970's (El-Rabbany, 2002; Sullivan, 2012). It provides continuous positioning and timing information under any conditions, providing accurate and up to date information on user locations. In the recent years, GPS has grown to become a must have feature in smart mobile devices, with almost every single device in production right now having it pre-installed (El-Rabbany, 2002; Sullivan, 2012). Companies like Google have used this rise in GPS hardware to their advantage using applications like maps to provide location services accurate to within 5 metres depending on one's surroundings (Patterson, 2016). Figure 2.6 shows how the GPS system works.
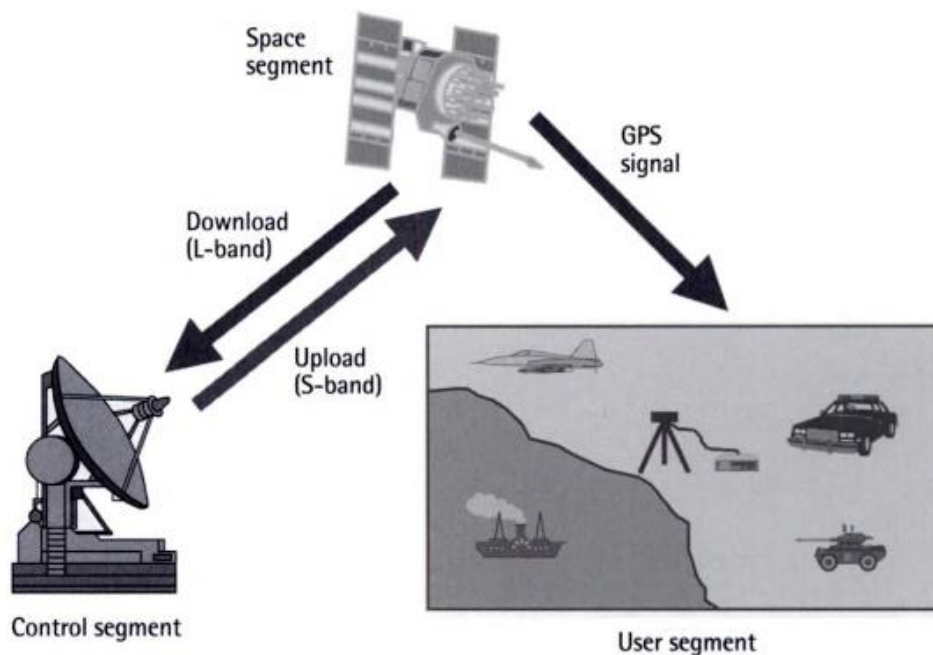
Figure 2.6: How GPS works (Adapted from El-Rabbany 2002)

With such high accuracy figures, marketers have come up with ingenious ways to market goods and services to clients, a method called location marketing (Henriksveen, 2016; Patterson, 2016). They leverage on the power and accuracy of GPS, location services and context aware services to deliver marketing material, adverts and offers to user devices when they are in a specific geographical location. Despite all of this, the main shortfall of using GPS to provide context for smart devices is that it can only provide accurate location information vertically, but not horizontally (El-Rabbany, 2002). If a user device is inside a building with several floors, it will

tell you with a great degree of accuracy that the phone is in the building, but it will not give you information on which floor the device is on.

2.6.2 Context Awareness Using WiFi

Context awareness for smart devices can also be achieved using Wireless Fidelity (WiFi) which is a wireless networking technology that allows computers and other devices to communicate with each other and to connect to the Internet over a wireless network (Cisco, n.d.; Mitchell, 2017). It can be used to create context awareness when a user uses a device to connect to a network at a location. Once connected to this network, their mobile device can know where they are and what resources are available around them. This will enable it, through a mobile application, to be able to execute certain tasks or provide certain services to the device user (Namiot, 2012; Tong, 2014). Figure 2.7 shows how a simple wireless network works in connecting devices to the internet and each other.
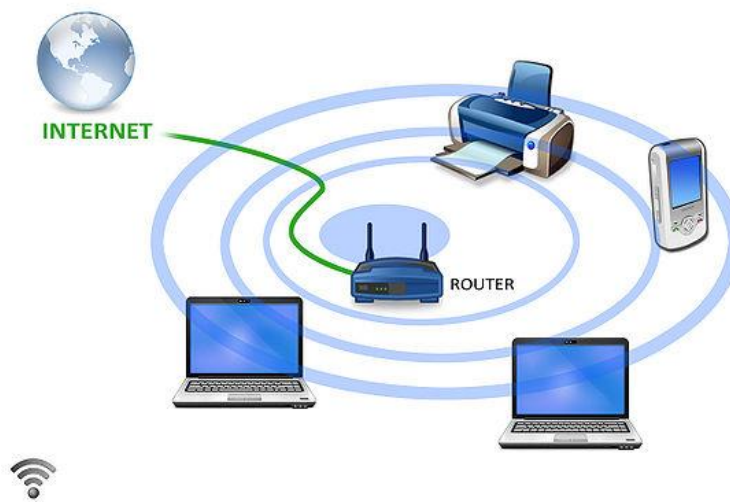
Figure 2.7: How WiFi works (Adapted from Namoit 2002)

Wireless networks can also be used to gauge proximity to a location depending on the strength of the signal being emitted from the wireless router. Essentially, the stronger the network signal, the closer the device is to the source of the signal (Namiot, 2012; Tong, 2014). This means that marketers can set up proximity based marketing techniques to ensure that people within this range can receive specific, targeted advertisements and information on their devices. The biggest short coming with this method however is that a user's accurate position cannot be determined. Using

wireless networks for proximity marketing can work on a large scale, but cannot provide information on a micro level.

2.6.3 Context Awareness Using BLE Beacons

Achieving context awareness using Bluetooth Low Energy beacons is another way to achieve context awareness, and is the basis of the application to be developed for this research. A BLE beacon is a radio device that uses Bluetooth Low Energy, a wireless personal area network technology, to transmit a unique set of identifying numbers to nearby listening devices (MBED, 2015; Statler, 2016; Thompson, 2013). According to MBED (2015), a beacon transmits 4 manor pieces of information which include:

I.   A Universally Unique Identifier (UUID) which is used to identify the beacon.
II.   A major number which is used to identify a subset of beacons within a large group.
III. A minor number identifying the specific beacon
IV.   A TX power level which indicates the signal strength. This can be calibrated by the user or manufacturer and will directly affect battery life.

These devices have a small range, transmitting from distances as low as 1 metre to as large as 70 metres (Droidcon, 2016; Gonzalez, 2015; Leddy, 2015). The signal is however susceptible to interruption or breaking depending on environmental factors so most of them are limited to very small, indoor spaces with little to no radio interference. Figure 2.8 shows how a context aware system works using beacons. Figure 2.9 shows the different types of beacons from different manufacturer currently available in the market.

Figure 2.8: How Bacons Work (Adapted from infodisplay 2015)

Figure 2.9: Beacon Manufacturers (Adapted from ITtechcraft, 2015)

The hardware of a beacon consists of a microcontroller coupled with a Bluetooth LE radio chip and a battery (Aislelabs, 2015; Statler, 2016). With the new standard of Bluetooth, these devices

are far smaller than their predecessors which used Bluetooth Classic, which used more energy and required larger batteries as shown in Figure 2.10.
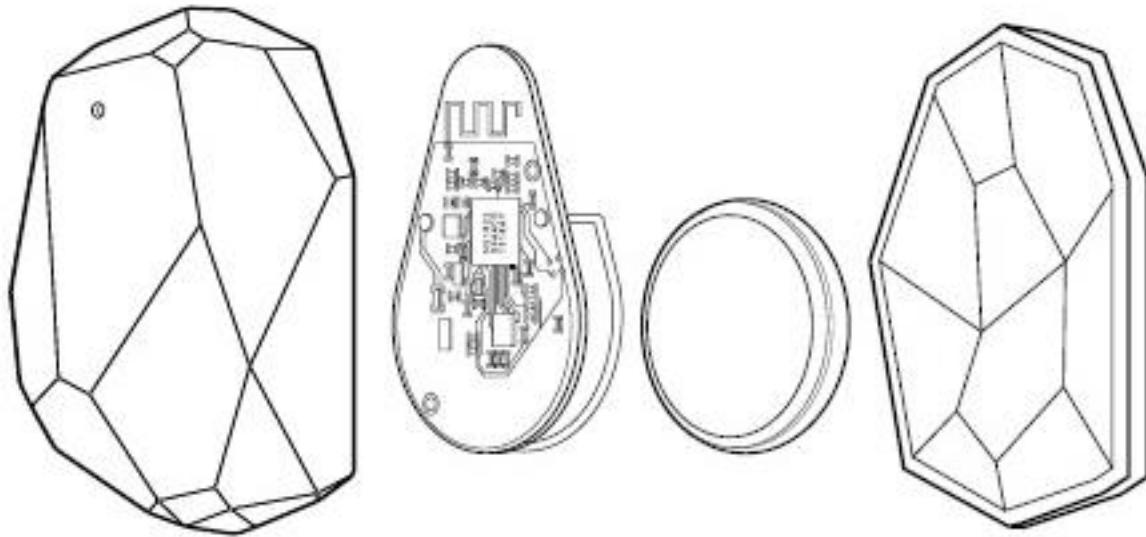
Figure 2.10: Inside an Estimote Beacon (Adapted from Aislelabs, 2015)

2.6.3.1 Review of Beacon Manufacturers

There are multiple Bluetooth Low Energy beacon manufacturers in the market providing varying services along the same lines. This section looks at some of the manufacturers in the market and the products that they have to offer:

Kontakt IO

This is one of the biggest and most affordable beacon manufacturer in the market at present, competing with Estimote directly (Shea, 2015; Aislelabs, 2015; qliktag, 2015). It offers two standard location-based technologies in the form of the Smart Beacon and the Rugged Beacon. The smart beacon is built for use indoors with Nordic Semiconductor chip, contain an ARM Cortext-M0 core, the ability to receive Bluetooth packets 50 metres away and a battery life of up to two years (Aislelabs, 2015; Shea, 2015). The Rugged beacon on the other hand is built for outdoor use being shutter resistant, water proof and capable of working under extreme temperature conditions ranging from -4 to 140 degrees Fahrenheit. Figure 2.11 shows Kontakt IO Beacons.

Figure 2.11: Kontakt IO Beacons (Adopted from AISLabs, 2015)

Radius Networks

Radius network founded in 2011 offers a varying number of beacons including the RadBeacon Dot, RadBeacons USB and the RadBeacon X4. The RadBeacin Dot is the smallest of the three devices offering a range of between 5 to 50 metres and a battery life of between 30 days to 285 days (Shea, 2015; qliktag, 2015). The USB beacon offers a range of between 5 to 30 metres and is powered using a USB charger (laptop port). The X4 is the rugged version of the RadBeacon offering a range of between 5 to 50 metres, 184 months battery life and resistance to the elements. Figure 2.12 shows the RadBeacon Dot.

Figure 2.12: RadBeacon Dot (Adopted from AISLabs, 2015)

Gimbal

Launched in 2013 by Qualcomm, the Gimbal is designed to take on the BLE Beacon market with a minimalist design, a range of up to 50 metres and a battery life ranging from 1 year to 3 years depending on usage. It is similar to the Estimote, Kontakt and RadBeacons in many ways including price, ranging from 50-100$ for a set. Just like the other three, it provides a state of the art management system which allows users to automatically track and manage beacons regardless of location, whether indoors or outdoors. The major downside of this beacon is that Qualcomm have a per-user fee which could push users away from it. Figure 2.13 shows the Gimbal beacon by Qualcomm.

Figure 2.13: Gimbal Beacon (Adopted from AISLabs, 2015)

Estimote

Estimote beacons are some of the most versatile beacons in the market right now. They offer a combination of security, reliability, battery life, performance and all weather proofing that most others do not (Shea, 2015). It boasts a default battery life of about three years, a range of up to 70 meters, and an ARM Cortex-M0 core processor. They were chosen as the beacons for this research due to their many processing advantages and availability. Figure 2.14 shows the Estimote Beacons.
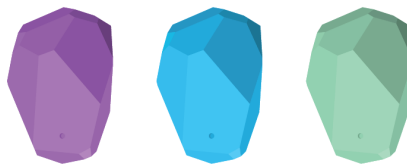

Figure 2.14: Estimote Beacons (Adapted from AISLabs, 2015)

2.7 Existing Context Aware Applications

2.7.1 Launch Here Application

The Launch Here Application is a mobile application designed for the IOS platform that uses the power of BLE IBeacons and context aware services to open location specific applications when you are in the correct context. It uses BLE beacons to mark areas where certain applications are most used and deploys these applications when the user device is within the vicinity. In the case of when the user is in the house, beacons can be placed next to the sofa set, the bed, the kitchen or the door. On entry into either of these locations, the user device discovers the beacon and alerts the user of its presence. It then goes ahead to deploy an application (in the case of the bed, the alarm application), enabling the user to interact with and make changes to them as shown in Figure 2.11. In the case where context is lost and the user device is too far from the beacon, it looks for another device to provide it with context or takes away the previously deployed services (Launch Here, n.d.).
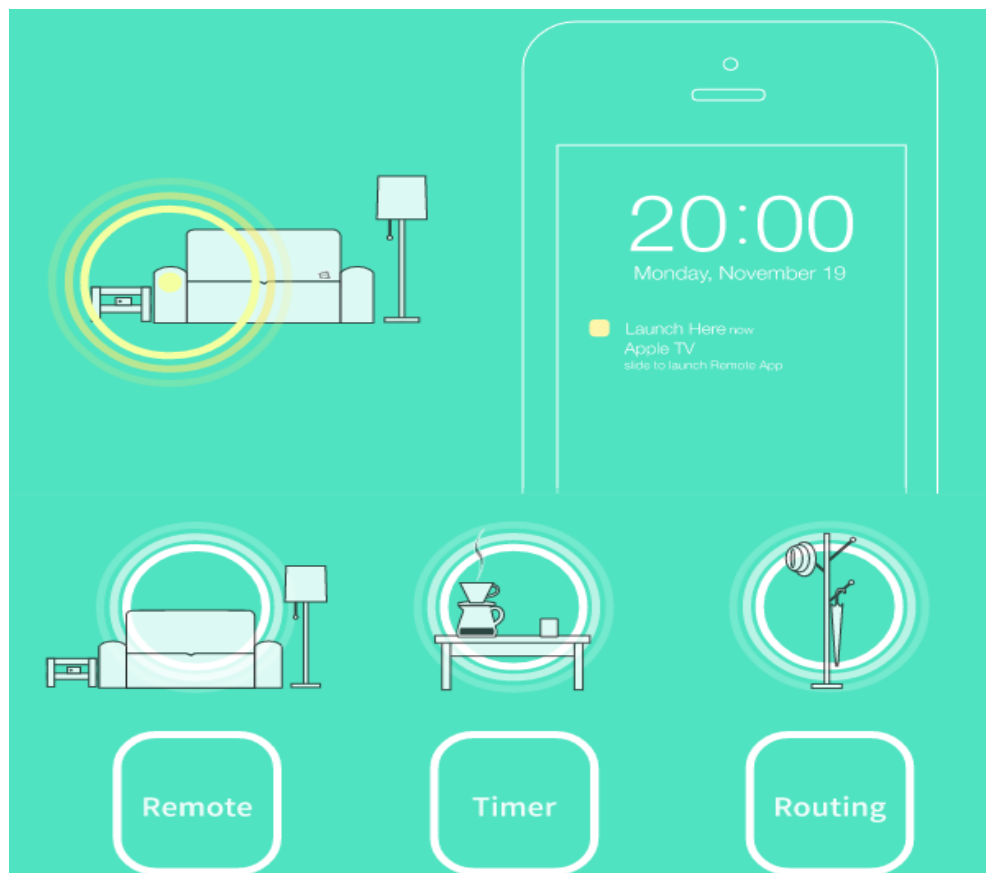

Figure 2.15: Launch Here Application Demo (Adapted from Launch Here, n.d)

This system is useful in a variety of ways such as providing its users with easy access to location specific applications without them necessarily having to browse through their devices to find them. It also gives users control over their homes and personal spaces, providing them with the ability to change things just from a click on their mobile devices.

The major drawbacks of this system however are in the fact that it is only available on the IOS platform meaning that users of other platforms cannot access these services. It also does not allow for user information input, limiting the users to only opening applications and links.

2.7.2 Be Here Application

Be here is a mobile application designed for the IOS platform which uses the power of BLE IBeacons and context aware services to check class attendance in institutions of learning. The application is set up to work with beacons which monitor class attendance by linking directly with student devices and showing results on the teacher's device (Pavithra, 2015). The teacher starts a new session and posts it up using Apple TV. The students then walk into class with their iPhones, iPads or iPods already preloaded with the application and are immediately recognised by the teacher's device, which posts their names on the Apple TV. The application goes a step further to provide learners with a chance to interact directly with their teachers and their fellow students by providing chat facilities for enhanced interactions. It has a variety of useful features which help automate class attendance registration process.

The major drawbacks of this system are however in the fact that they are restricted to Apple products using the IOS platform which is harder to access for learners than Android based devices due to their substantially higher prices. It is also at risk of being tricked by learners looking to skip class. In the case of a large class number, a learner can walk in with multiple devices belonging to registered students. It can also not be able to register class absence if the student walks in with the mobile device and leaves half way through the class leaving their mobile device in class (Beelieve, n.d.). Figure 2.12 shows how the application demo.
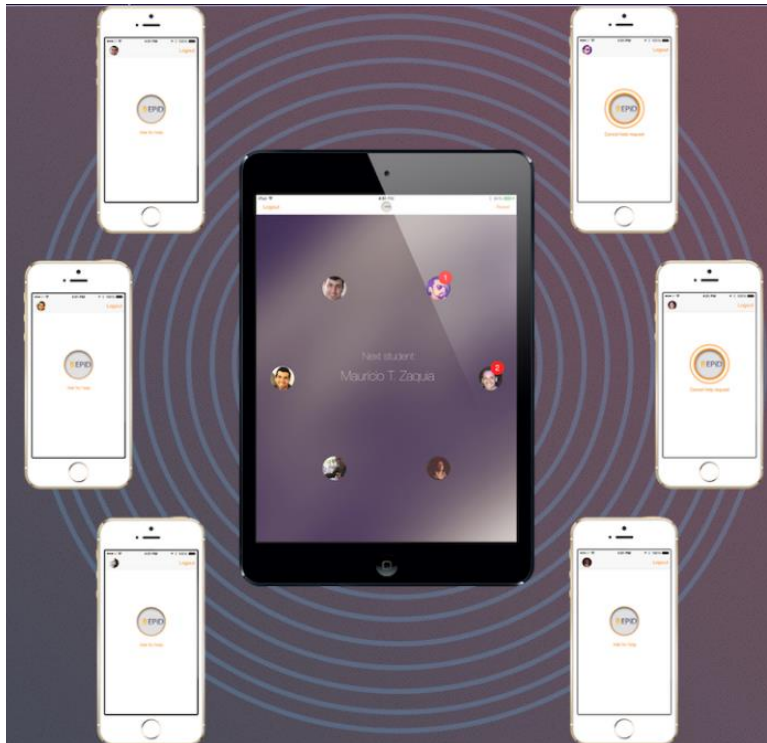
Figure 2.16: Be Here Application Demo (Adapted from Beelieve, n.d)

2.7.3 SITA OnAir

SITA OnAir is a mobile application aimed at the aviation sector which uses BLE beacons to promote in flight usage of wireless networks and other resources available to passengers while in transit. The applications primary function is sending notifications to users about available wireless networks within airports and in flights. Beacons placed at strategic locations are used to push notifications directly into user devices when wireless networks are available (Pavithra, 2015).

This application has helps users find available wireless networks and connect to them in the easiest way possible as shown in Figure 2.13. It removed the need for users to have to go around asking for Wifi passwords or airlines having to stick up notices about passwords on walls. The down side of this application is that it is limited in the content that it provides to the user, limited to wireless network information. It also works primarily for the IOS platform locking Android device users (SITA on Air, n.d).

Figure 2.17: Launch Here Application Demo (Adapted from SITA on Air, n.d.)
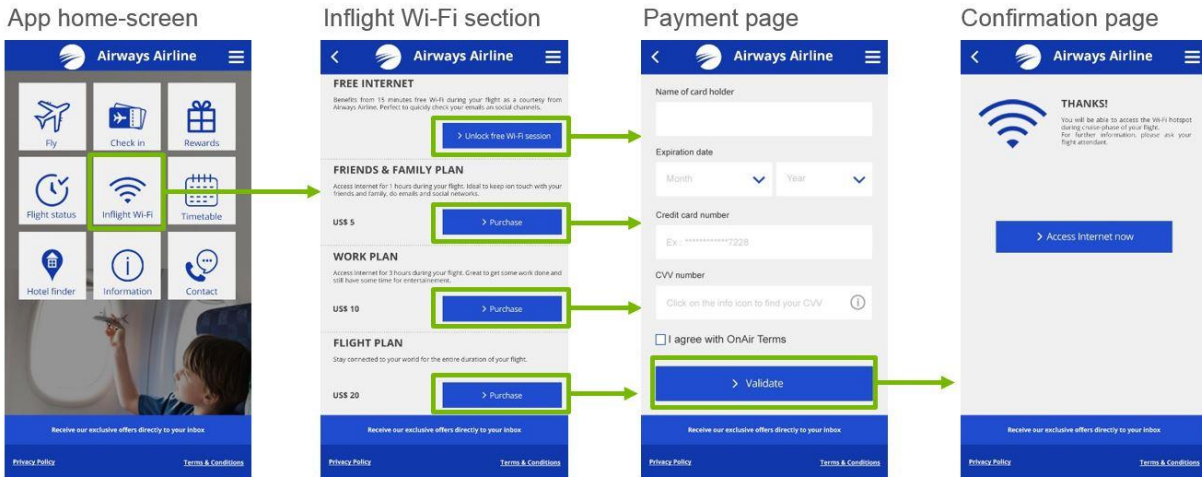
2.8 Gaps and Limitations

Following the review of systems currently in place for communicating with students in institutions of higher learning, it is clear that there is a need to employ systems that utilize context aware services and put to good use the smart mobile devices that students currently have. Systems like email, websites and social media have been seen to have shortfalls, leaving most messages undelivered to the desired recepients due to information overloads, lack of context, a general shoft towards more digital platforms and many more.

This research has also looked at the various methods that can be examined to be applied to achieve context awareness for smart devices. It touched on the use of GPS and location services to provide location based advertising and marketing, a technique that is quite effective but with sort comings. The major short coming is in the fact that it can only be used to gauge location vertically but not horizontally. This means that a device can accurately be tracked to a building, but telling what floor the device is on is impossible.WiFi was also examined as a seperate method of providing context to a smart device, its major short coming being that it is difficult to gauge the distance of a device from the signal source.

The Smart Noticeboard mobile applocation and web back end aims to bridge some of the gaps identified in information dissemincation through the various channels discussed in this section. It employs a technology that is both user friendly, cheap and effective, delivering information to

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mobile devices through a mobile application when the user is in the correct and most actionable context.

2.9 Conceptual Model

The proposed model will use BLE Beacons to provide contextual information to the user's mobile device through a mobile application. Figure 2.14 shows the conceptual model for the proposed system. The base station will be used to transmit data to and from the internet between the mobile device and server.
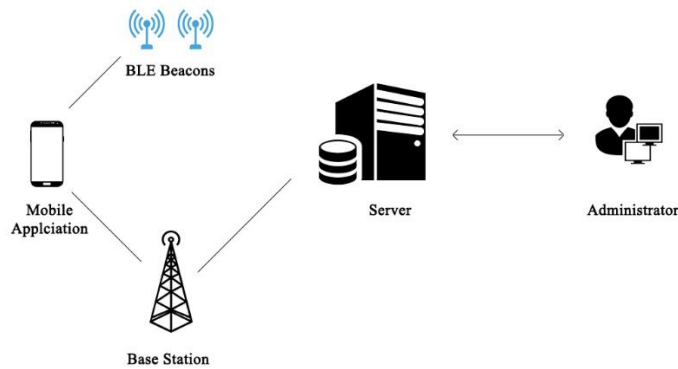
Figure 2.18: Conceptual Model

2.10 Conclusion

The current methods of information dissemination on campus are at best unreliable, unefficient and ineffective. The proposal to come up with a mobile application to deliver smart notices to mobile devices using BLE Beacons is better justified given the more costly and unreliable alternatives currently available. This mobile application will not only unify some of the best parts of the currently available systems, but also act as a gateway to more applications that use the same context aware services to deliver information and services.

Chapter 3 : Research Methodology

3.1 Introduction

This study was aimed at developing an noticeboard application using the power of context aware services to deliver information to smart mobile devices. This section describes the research methodology used, stages of the research, location of the research, and purpose of the research, data collection techniques and analysis that was used.

3.2 Agile Software Development Methodology

Agile is a software development methodology that is based on the incremental and itterative approach where developers go through the analysis, design, development and testing phases a number of times, each time coming up with a functioning prototype for review by the client (Martin, 2008; Waters, 2007). It offers developers a chance to build software keeping the user and their requirements in mind (Smartsheet, n.d.). It offers the ability to assess the direction of the reseach throughout the development cycle, its processes accomodating release schedule and user feedback opportunities, allowing for faster and more controlled improvements (Agile Methodology, n.d.; CPrime, 2014). It was used in the development of this application for the following reasons:

   I.   Agile methodology can accommodate the ever growing and changing user requirements.

  II.   This mehtodology welcomes changes in requirements even late in development , its processes harnessing this change for the customers competitive advantage.

 III.   Unlike its competition, it allows development teams to remain competitive especially during long projects.

 IV.   The Agile methodology provides for a faster to market strategy with a greater guarantee of user acceptance due to constant user engagement through out the development process.

Agile methodology has five main phases ranging from planning, requirements analysis, design, development to testing (CPrime, 2014). Figure 3.1 shows the steps to be taken during the implimentation of the mobile application using Agile development methodology.

Figure 3.1: Agile Development Methodology (Adapted from Smartsheet, n.d.)

3.2.1 Planning Phase

This is the very first stage in the software development life cycle and is kept at a very high level, facilitating for the planning of how the entire process was undertaken (Agile Methodology, n.d.; Highsmith, 2011). It helped in the identification of the resources that were required for the successful completion of the system development. The researcher identified all the necessary resources required to develop a noticeboard application.

3.2.2 Requirements Analysis Phase

This is the second phase that involves the researcher figuring out what the system is expected to accomplish. It is important in revealing important information surrounding the process such as user requirements, development requirements like environments and parameters that should be in place to ensure successful development. In this stage the researcher went out to collect user requirements and development requirements.

3.2.2.1 Location of the Study

The study was carried out in Strathmore University in Madaraka, Nairobi County. It involved the communication department for the campus, the people who manage all notification, whether internal and external. The location was selected due to the high student population, most of whom have smart phones and are tech-aware and willing to experiment with new technologies.

3.2.2.2 Target Population

As of October 2015, SU had a population of 5,012 students enrolled to various courses from undergraduate diplomas and degrees to Post graduate Degrees (Strathmore Universty, 2015). The target population for this research involved students in Strathmore University who were placed into two groups. The first group was involved students who use the noticeboards and receive general messages from the communication department at SU. The objective of this exercise was to find out the frequency that the people in this sample group received messages from the University, if they ever interact with them or react to them, and if they ever interact with or used the notices on the public noticeboards. It also helped in determining user requirements. The second category involved students who were involved in the testing of the system. They were tasked with testing the application and its functionality, to see how effective the implementation was and what iterations were needed to be implemented before deployment.

3.2.2.3 Sampling

Considering the large number of people in the target population, a random sampling technique was be used which involved selecting a small sample population from people chosen at random.

$$n = \frac{NZ^2 \times 0.25}{[d^2 \times (N-1)] + (Z^2 \times 0.25)}$$

n = Sample size
N = Total Population size (known or estimated)
d = Precision level (usually 0.10 or 0.05)
Z = Z statistic for a level of confidence (e.g. 1.96 for 95% confidence level)

Equation 3.1: Random sampling (archive-edu, 2013)

Equation 3.1 shows the formula that was used to derive the sample population for this study, ensuring that of the people in the entire population, each had a similar probability of being chosen for the study.

$$n = \frac{5012 \times 1.96^2 \times 0.25}{[0.1^2 \times (5012 - 1)] + (1.96^2 \times 0.25)}$$

$$n = 91.831$$

Thus the sample size of the study was be 91 respondents.

3.2.2.4 Data Collection

Google docs and Google forms were used in data collection. The data collected for this paper was the usability results and interview results with the Usability questionnaire collecting data on what the users felt about the application and if it solved the problem at hand. Interviews were also conducted by the researcher a process that involved the use of a questionnaire shown in Appendix B. The guidelines assisted the researcher to come up with requirements and limitations of the existing systems as per the research objectives.

3.2.2.4 Data Analysis and Functional Modelling

Object Oriented Analysis was used to comprehensively analyse and model user requirements. It involved identifying all objects within the system and their relationships. System functionality was modelled using a use case diagram and corresponding descriptions. The system flow was modelled using a sequence diagram with the database being modelled using an entity relationship diagram showing all the tables within the database with their corresponding relationships and attributes.

3.2.3 Design Phase

After all the system requirements were identified and understood, the system design phase commenced. This phase involved the use of system design methods to represent the architecture of the system to be developed.

Unified Modelling Language (UML) was used as the modelling language to diagrammatically represent system requirements and the relationships between various components (Bell, 2003; Lynda, 2012). The functionality of the application was modelled using the following diagrams:

I.   Use Case Diagram: Use cases are used to visually represent the various interactions between the key stake holders in the system and the system itself (UML-Diagrams, n.d.; Bell, 2003; Lynda, 2012). In this phase a use case diagram and a corresponding use case description was developed detailing the various users, their interactions with the system and other possible use cases that might arise. From these use case diagrams, an activity diagram was developed detailing the sequence of activities happening in the system and even interactions between various entities.

II. Design Class Diagram: a design class diagram was used to represent all the classes used in the system and how they are defined. It shows the relationships between various objects,

their cardinality values, with the classes being defined using attributes and methods (Larman, 2009).

III.   Entity Relationship Diagram: This diagram enables diagrammatically represent the relationships between entity sets stored within a database. It helps in the normalization of tables in a database to eliminate redundancies (Larman, 2009).

IV.   Sequence Diagram: This diagram models the flow of logic within the proposed mobile application, visualizing how various users of the mobile application interact with the features (Larman, 2009).

V.   Database Design: The ERD enabled the researcher to come up with the database design which showed the various relationships between different entities and their attributes.

VI.   Wireframes: The system wireframes were designed using the Balsamic Wire framing tool, helping the researcher visualize what the finished application would look like.

3.2.4 Development Phase

In this phase, the system was developed based on the architectures and models developed in the design phase. This involved coming up with a mobile application and a web back end application both of which were linked to a single central database. The environments that were used include:

I.   Mobile Application: The mobile application was developed for the Android operating system, its source language being the Java programming language (Ableson, 2009; Grell, 2010). The Android platform was chosen due to its robust SDK, the Android developer tools, support from online developer communities and ease of development and integration with Bluetooth low Energy beacons for context awareness (Rishabh, 2014).

II.   Web Back-end Application: The web backend was built in Java Enterprise Edition, a platform built on the standard Java programming language which provides API's and runtime environments for developing and running large scale applications (Theedom, 2016; Versrynge, 2013). It was chosen because of its extensive collection of tools and resources, portability and its ability to handle with ease heavier applications and their demands.

III.   Database: MySQL was used as the primary database management system for both the web based backend and mobile application. It was chosen due to its open source nature and its

compatibility with the Android platform. It was used to handle user data, advert data, beacon data and location data (Wallen, 2016; Zetcode, 2017).

3.2.5 Prototype Evaluation and Testing

Once the system development was complete, it underwent a series of tests to ensure that it met all the objectives of the research, to ensure that it is user friendly and that it implements the design that was laid out for it. The tests conducted included:

I. **Usability Testing:** This was conducted to determine how useable and user friendly the application was. A total of 16 respondents were selected to test the application and give feedback regarding the application. The feedback was used to refine the application and to validate the system.

II. **Compatibility Testing:** This was conducted to ensure that both the mobile application and the web back end function as expected. The mobile application was tested on 5 different Android devices to ensure compatibility across multiple devices using the platform while the web back end was tested on 3 different web browsers.

III. **Functional Testing:** This was conducted to test out the systems functional and non-functional requirements.

IV. **Validation:** To validate that the application addressed the challenges of information dissemination using context awareness, a sample group of 10 respondents were chosen from the sample group to test the application to ensure that the process of receiving and saving notices using context aware services was complete. Feedback collected from the testing was analysed to come up with validation.

3.3 Conclusion

This chapter takes an in-depth look at all the methods that were used in the planning, analysis, design and development of the smart noticeboard application. Through the methodology, the research is able to come up with a clear roadmap of the prototype implementation process taking into account the software methodology and the tools required.

Chapter 4 : System Analysis, Design and Architecture

4.1 Introduction

This chapter focuses on the analysis, design and architecture of the proposed system centred on the user requirements and methodologies proposed in the previous chapter. This was achieved through use case diagrams and their detailed descriptions, System Sequence Diagrams, Design Class Diagrams, Entity relationship Diagrams and Security Design.

4.2 Requirements Analysis

Detailing the features, constraints and services that should be addressed by the Smart Noticeboard mobile system can be split into functional and non-functional requirements.

4.2.1 Functional Requirements

Functional requirements describe the processes that the application is going to execute. Table 4.1 is a physical representation of the requirements and what the users are able to achieve with the system. These requirements are described in greater detail in a use case diagram (Figure 4.1)

Table 4.1: Functional Requirements

No.	Functional Requirement
i	Users should be able to register with the system.
ii	Users should be able to login and verify their account via proximity tests.
iii	Users should be able to view information transmitted on the closest beacons to their locations.
iv	Users should be able to save information being transmitted through the BLE beacons.
v	Administrators should be able to add, modify and remove posts tied to individual BLE beacons.
vi	Administrators should be able to activate or deactivate BLE beacons in specific locations.
vii	All users should be able to log out of the system.

4.2.2 Non Functional Requirements

Non-functional requirements are considered non-essential parts of the system that make the system more interactive, user friendly and easier to use for the users. Despite the fact that the system would be able to work effectively without these requirements, they form an integral part of this study which looks at both the functional and non-functional requirements in the making of a complete system. A complete system looks beyond just the system requirements, focusing on the users and their requirements as well. Table 4.2 describes the non-functional requirements of this system:

Table 4.2: Non Functional Requirements

No.	Non-Functional Requirements
i	The application should be able to run on all Bluetooth Low Energy enabled Android smartphones (Android 4.4 Kitkat and above).
ii	The application should ensure seamless access to notices when within range.
iii	The application should be smart and easy to use.
iv	The application should ensure integrity of data from administrator to users.
v	The application should provide smart error and notification handling mechanisms.
vi	The system should be easy to scale accounting for future improvements and upgrades in a cost effective manner.
vii	The system should be able to handle multiple user requests and accesses without fail.

4.3 Data Analysis

Data for this research was collected using both interviews and questionnaires. The questionnaire was presented on Google forms to facilitate for data analysis. Interviews were conducted on a one on one basis, focusing on students likely to use the system. Of the 91 respondents that were supposed to take part in the research, 70% of them were allocated to taking part in the questionnaire and one on one interviews. The other 30% were tasked with testing the functionality of the developed application.

4.3.1 Degree of Response

The target population was comprised mainly of students with the research getting a response rate of 60% of the target population. This was due to a time constraint on the research, limiting the researcher on the number of collected responses.

4.3.2 User Responses

The questionnaire sent out to the students gave the following feedback:

4.3.2.1 Current Mobile Device in Use

The question was meant to find out the smart phone penetration amongst the sample group. 98% of the respondents have smart phones while only 2% had feature phones as show in Figure 4.1.
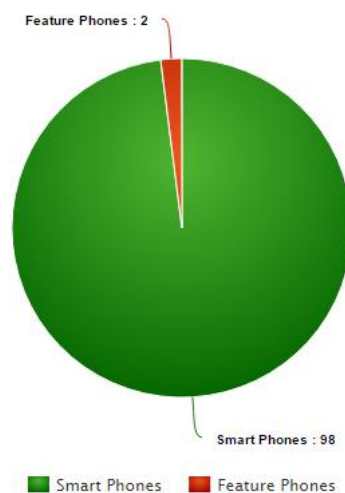

Figure 4.1: Smartphone Penetration

4.3.2.2 Operating System on Mobile Device

The question was meant to find out the type of operating systems that the respondents were running on their mobile devices. This was imperative due to the fact that the research was hinged on the Android platform. 80% of the respondents had smartphones running the Android operating system, 8% had devices running the Windows for mobile operating system, 10% were running the IOS operating system while 2% were running other operating systems as show in Figure 4.2.
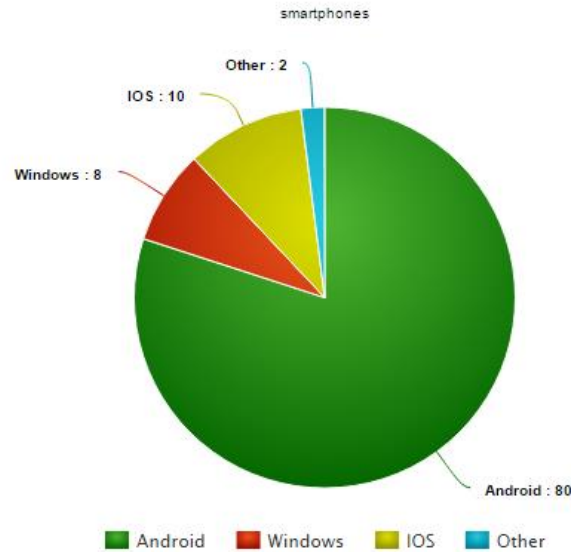

Figure 4.2: Operating Systems in Use

4.3.2.3 Android Version on Device

The question was meant to find out the version of Android for the users who said that they had Android devices. This is imperative as the use of BLE Beacons requires a minimum of Android version 4.0 with BLE capabilities enabled. 30% of the respondents said that they had Android version 6.0, 40% of the respondents had version 5.0, 25% had Android version 4.0 while 5% responded that they had android 3.0 and below as show in Figure 4.3.
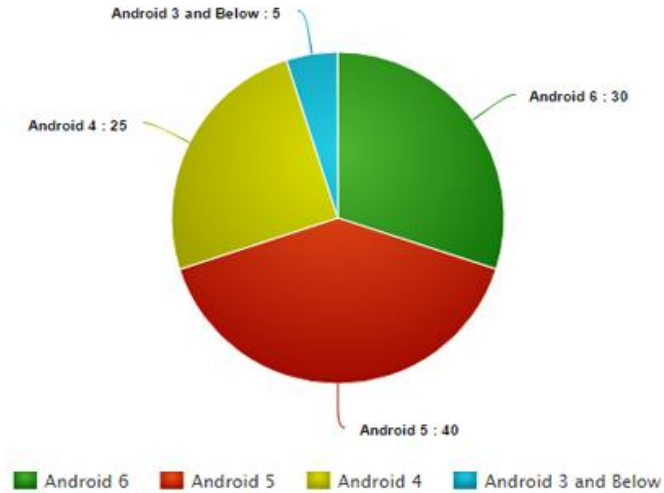
Figure 4.3: Android Version in Use

4.3.2.4 Main Source of Campus Essential Information

The question was meant to find out what the respondents main source of campus essential information was. 70% of the respondents said that they get information via email, 15% via noticeboards, 5% via social media and 10% via the official website as show in Figure 4.4.
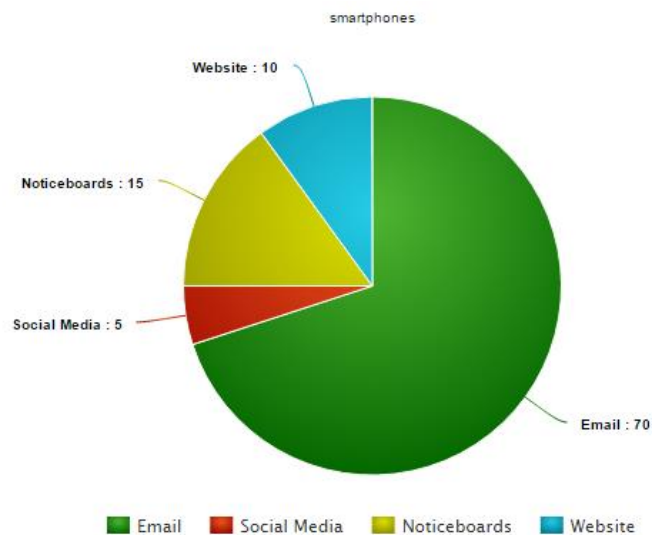

Figure 4.4: Media Most Used for Campus Communication

4.3.2.5 Frequency of Noticeboard Use

The question was meant to find out how frequently respondents interacted with information on noticeboards on campus. 90% of the respondents said that they never interacted with noticeboards while 10% said that they did as shown in Figure 4.5.

Figure 4.5: Noticeboard Usage

4.3.2.6 Ease of Notice Action

The question was meant to find out if respondents would find it easier to act on notices if they were able to store them on their smart phones. 70% or the respondents said yes while 30% said no as shown in Figure 4.6. This shows that a vast majority of people who interact with notices would find it easier to share and respond to notifications if they had them available on their mobile devices.
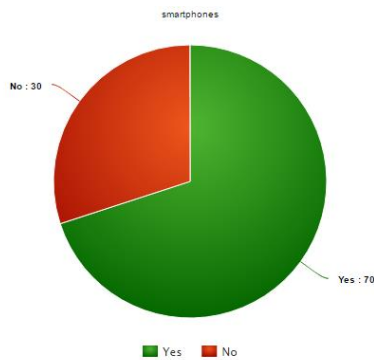

Figure 4.6: Ease of Notification Actionability

4.3.2.7 Spamming Reduction

The question was meant to find out if respondents felt that spamming and information overloads would be reduced if they could only receive notifications when they are in the correct and most actionable context. 88% of the respondents said yes it would and 12 % said no as show in Figure 4.7. This shows that a vast majority of students would prefer to receive information in the best and most correct contexts showing that building an application using context aware services is necessary.
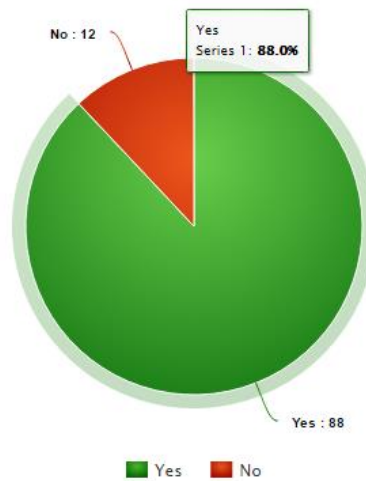

Figure 4.7: Spam Reduction Using Context Aware Services

4.4 System Architecture

The smart noticeboard system has the following actors: Users (Anyone within campus looking on campus relevant information that would otherwise be found on noticeboards), communication department staff (Update notices and information on display) and Administrator (responsible for the whole system). Figure 4.8 shows the system architecture for the proposed smart noticeboard system.
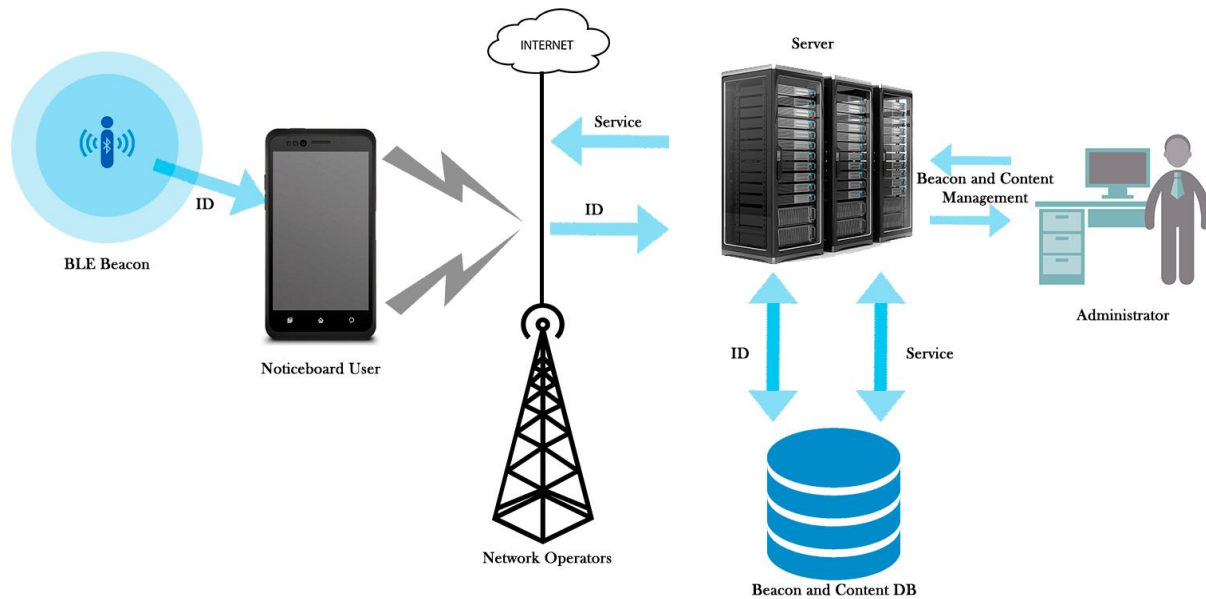

Figure 4.8: System Architecture

In Figure 4.8, the Bluetooth low energy beacon transmits a unique ID which can be detected by the mobile device and processed by the mobile application. The application then sends the ID to the server which matches it to the relevant service on the database and sends the link to the service back to the mobile application. The user is then able to access the relevant, context ready information on their mobile device. The mobile device remains in constant communication with the BLE Beacon and the server ensuring that the context remains relevant. In the case where a user strays too far and is out of the beacons range, the mobile application queries for alternative beacons to pull information from. If they are available, the information is displayed on the user mobile device. It they are not available, the mobile device shows the default screen alerting the user that it cannot detect any beacons.

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4.4 System Design

A blend of user specific requirements and ideas from the researcher were used to come up with the most relevant system designs that would help achieve the objectives laid out. The following design diagrams and their descriptions are what were used to guide the system implementation process.

4.4.1 Use-Case Diagram

The use case diagram was used to visually illustrate the different functionalities of the system relative to the actors involved and the goals that they are meant to achieve. Figure 4.9 shows the various use cases and their respective actors.
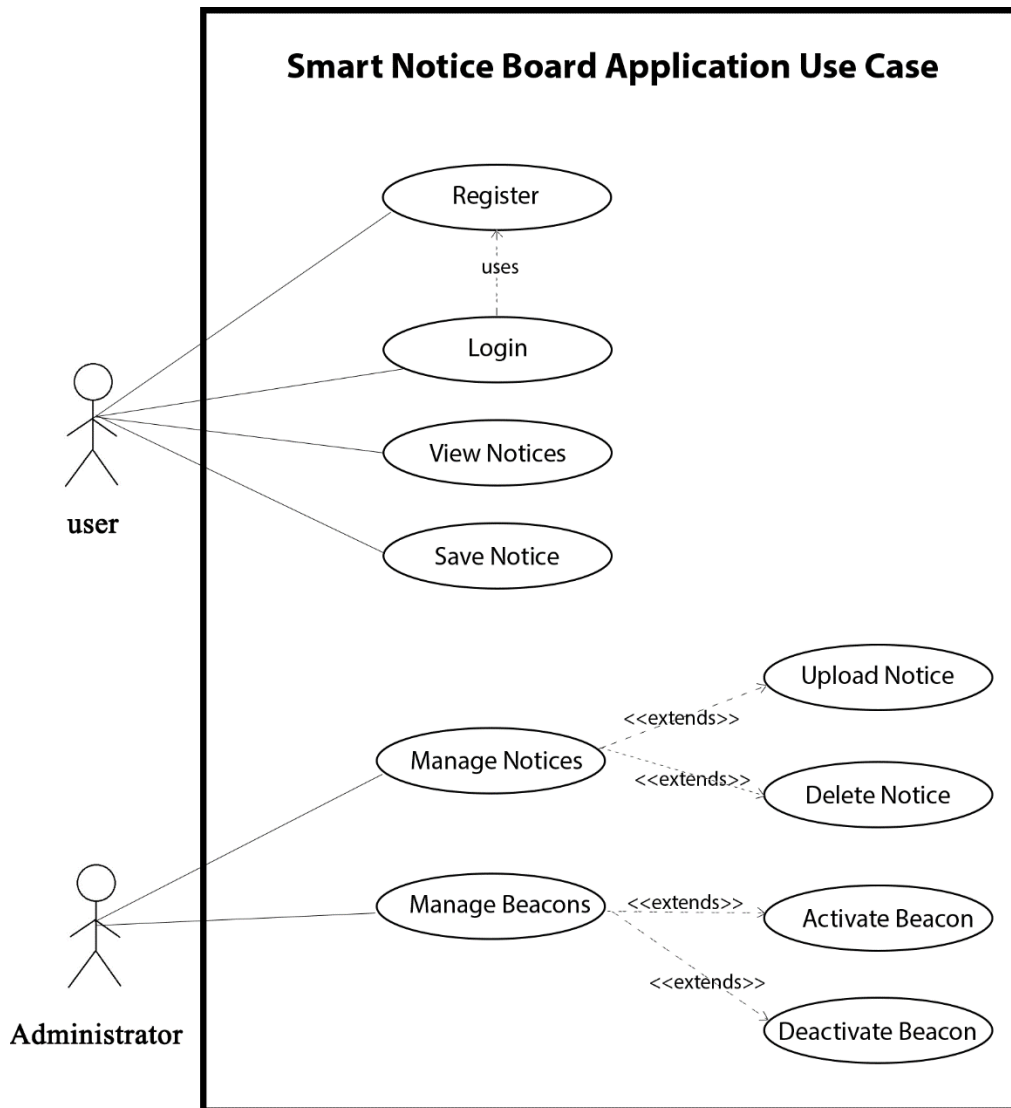

Figure 4.9: Use Case Diagram

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4.4.2 Use-Case Description

Table 4.3: Registration Use Case

Use Case:	Registration
Primary Actor:	Student
Stakeholder:	A student wants to receive smart notices through the system
Precondition:	A student has an active Bluetooth Low Energy connection on their mobile device.
Post condition:	The student should be able to access the login function.

Table 4.4: Login Use Case

Use Case:	Login
Primary Actor:	Student
Stakeholder:	Student wants to access active notifications.
Precondition:	a) Student has successfully registered. b) Student has input the correct login credentials
Post Condition:	Student should be able to login successfully and be able to access locked features

Table 4.5: View Notices Use Case

Use Case:	View Notices
Primary Actor:	Student
Stakeholder:	Student wants to read active notices.
Precondition:	a) Student has successfully logged into the system. b) Student has an active Bluetooth connection
Post Condition:	Student should be able to view notices corresponding to the nearest BLE beacon to their mobile device.

Table 4.6: Save Notices Use Case

Use Case:	Save Notices
Primary Actor:	Student
Stakeholder:	Student wants to save active notices to mobile device.
Precondition:	Student has successfully viewed active notifications.
Post Condition:	Student should be able to save notifications as images to their mobile devices for offline use.

Table 4.7: Manage Notices Use Case

Use Case:	Manage Notices
Primary Actor:	Administrator
Stakeholder:	Administrator wants to upload or delete active notifications.
Precondition:	Administrator has successfully logged into the backend of the system.
Post Condition:	Administrator deletes an active notification and uploads a new one.

Table 4.8: Manage Beacons Use Case

Use Case:	Manage Beacons
Primary Actor:	Administrator
Stakeholder:	Administrator wants to activate or deactivate a beacon.
Precondition:	Administrator has successfully logged into the backend of the system.
Post Condition:	Administrator activates and deactivates target beacons.

4.4.3 Sequence Diagram

The general functionality of the proposed system is to send out notifications using BLE Beacons only when a user is in the correct context. The system should at all times be looking for beacons within its environment and should automatically switch to the closest one to the mobile device. Figure 4.10 shows the information flow of in sequence passing through the main entities in the system.
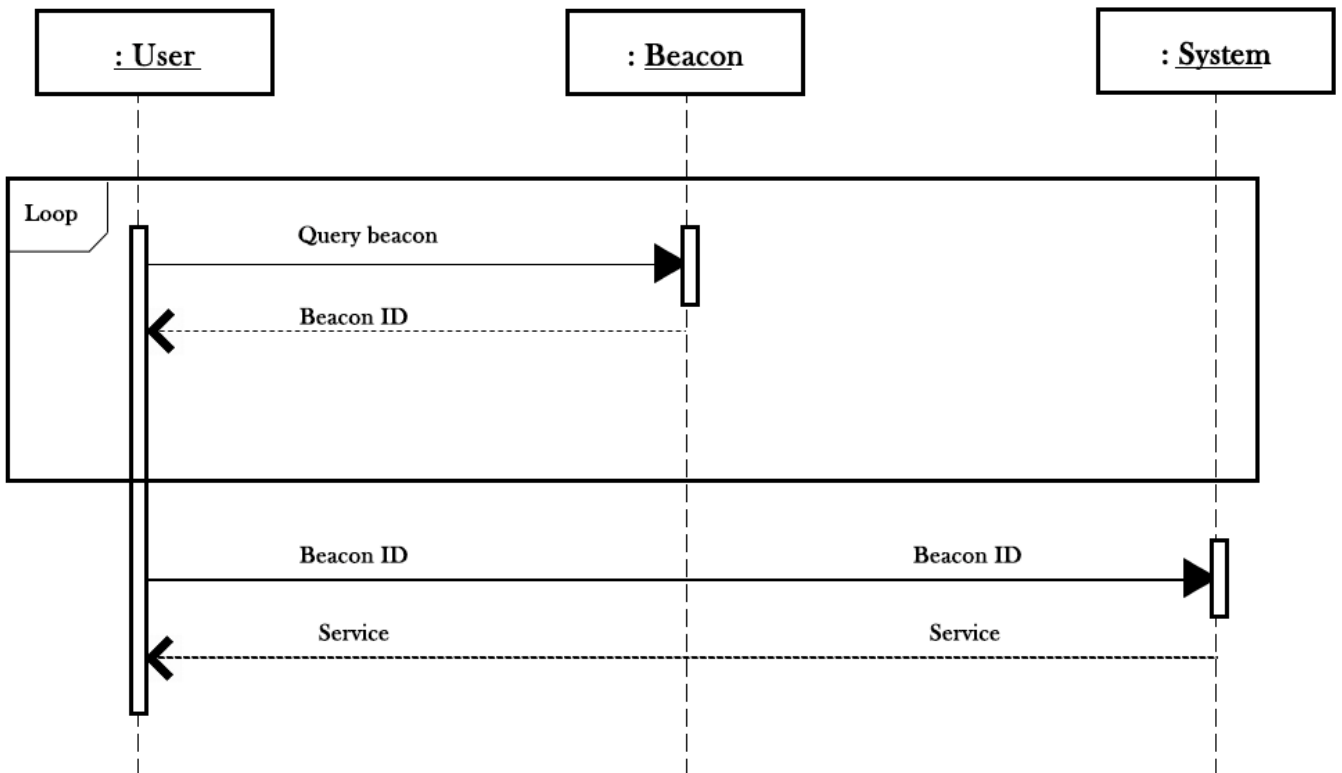

Figure 4.10: System Sequence Diagram

4.4.4 Design Class Diagram

The interaction of all the classes in the system and their corresponding attributes and methods are shown in Figure 4.11:
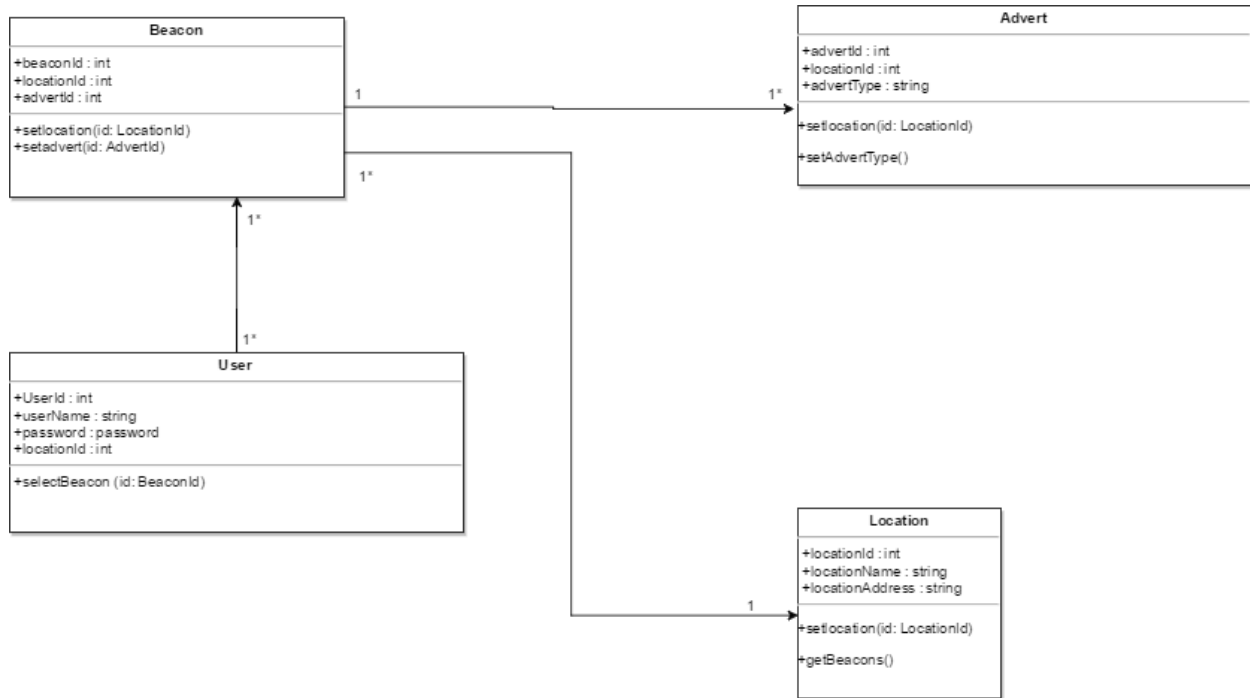

Figure 4.11: Design Class Diagram

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4.4.5 Entity Relationship Diagram

All of the entities used in the database to store data that can be accessed both from the mobile application and the administrative back-end are represented in Figure 4.5:
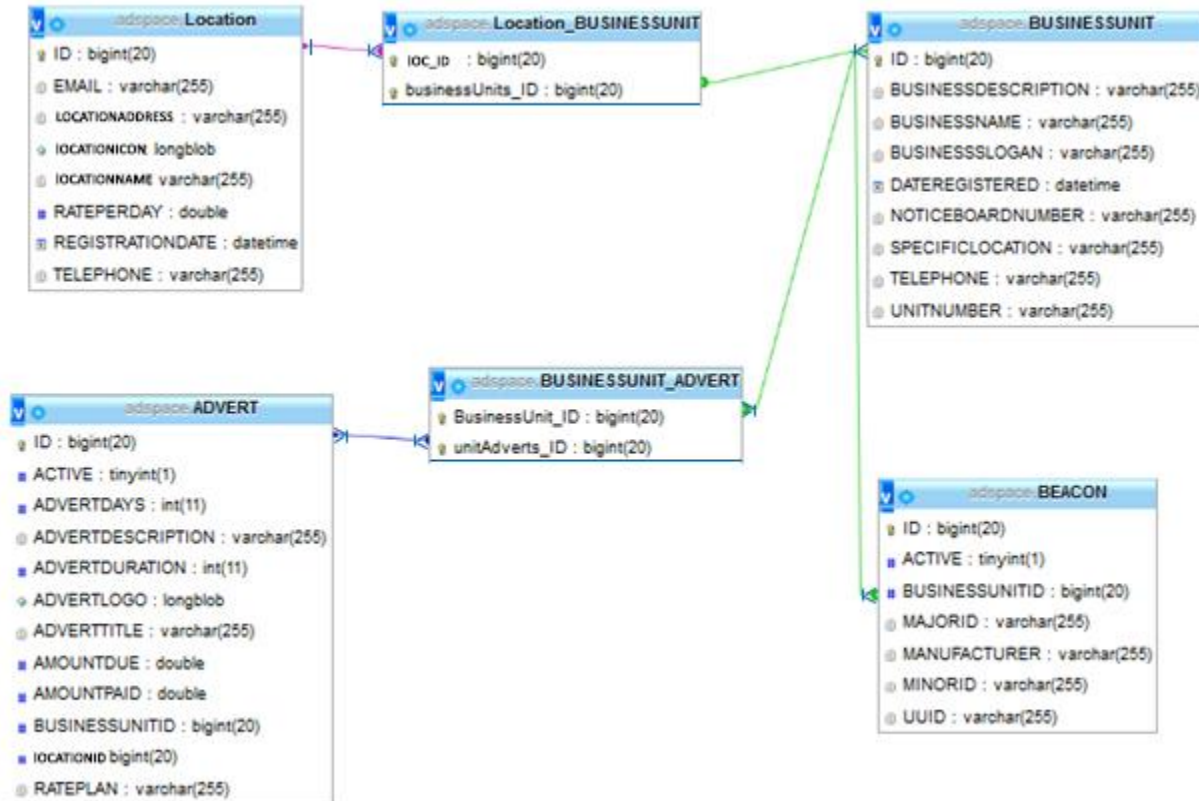

Figure 4.12: Entity Relationship Diagram

4.5 Application Mockups
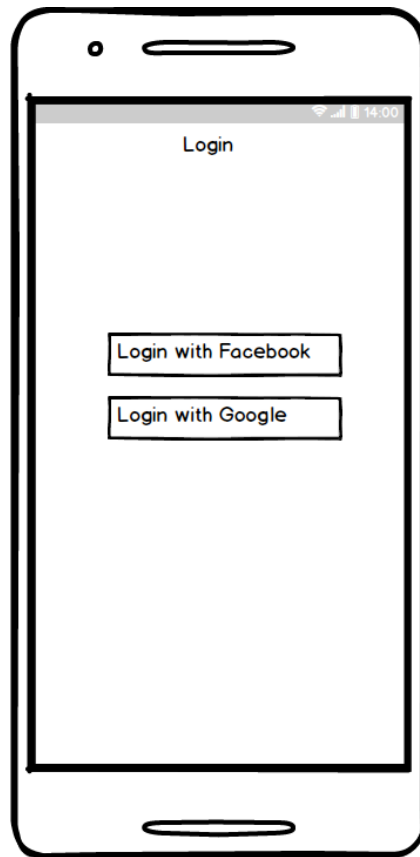
4.5.1 Mobile Application Wireframes

Figure 4.13: Application Login

After the application user has downloaded and installed the mobile application on their device, they will be required to login either by connecting with their Facebook or Google accounts in order to proceed to the next step.

Figure 4.14: Application Dashboard

After login is completed, the user is then directed to the dashboard where the application looks for any available beacons from which to display information. In the event that there are beacons available, the application downloads available material which the user can interact with.

Figure 4.15: Advert Expanded View

Once the adverts are on display, the user can click on an advert to expand and get more details, save or click on links to take them to external web pages.

4.5.2 Administrative Back-end Wireframes

An administrator has the ability to add, remove and modify locations, beacons and adverts through an administrative back end which can be accessed through a login page as shown in Figure 4.16:

Figure 4.16: Administrative Login

The administrator then has access to the dashboard from which they can add and remove locations, beacons and adverts as shown in Figure 4.17:

Figure 4.17: Administrative Dashboard

Chapter 5 : System Implementation and Testing

5.1 Introduction

This chapter focuses on the implementation and testing of the proposed Smart Noticeboard system. The implementation part of this section looks at the different parts of the system, how they were developed and how they work. It looks at the front end mobile application for the users and the backend web based system for administrative purposes. The testing section looks at functionality and usability testing, ensuring that the application meets all of the requirements and objectives that have been established in previous chapters.

5.2 System Implementation

The Smart Noticeboard application was developed using a native mobile development language and web technologies. The programming language used in this case is Java with the native system being the Android version 4, allowing devices running Android 4.0 (Ice Cream Sandwich) and above to run the application. The web technology used to develop the systems backend was Java EE linked to a MySQL database. These two systems are diagrammed and explained below.

5.2.1 Mobile Application

The Smart Noticeboard application was developed on the Android platform for use by students. It requires a mobile device with an Internet connection, Bluetooth Low Energy capabilities and running Android 4.0 and above. Students will use the application to scan for nearby BLE Beacons, retrieve information from them and access notices intended for those locations.

5.2.1.1 User Login

After the application has been downloaded onto the user device, users will be required to login using social media accounts or a Google account as shown in Figure 5.1 below:
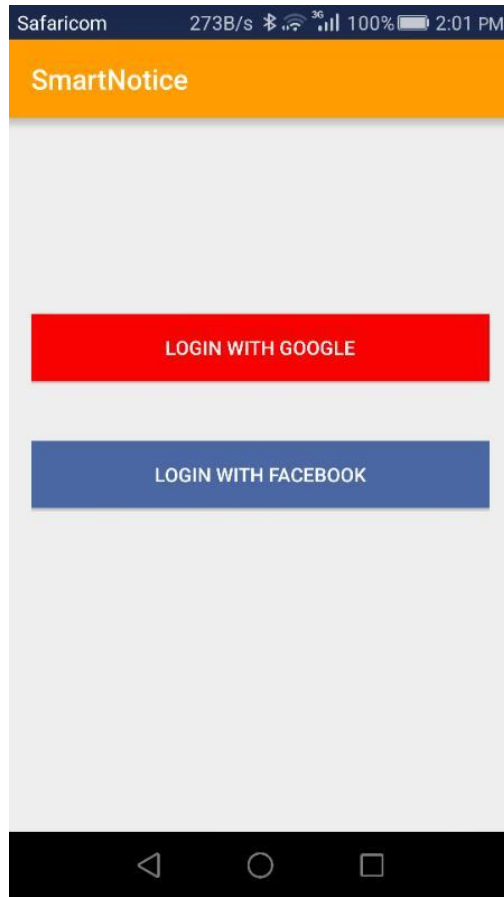
Figure 5.1: User Login

5.2.1.1 Application Dashboard

Once the user is successfully logged in, they are taken to the dashboard which shows available content from nearby beacons. In the event that there are no beacons available, a message will be displayed informing the user to look for beacon locations in order to access content. Figure 5.2 shows the dashboard with a notice displayed from a nearby beacon. A user can then go ahead to interact with the available notification. On clicking on it, a page is opened with a more detailed description of the advert showing a larger image, more details and the option to save or follow a link to another web page as shown in Figure 5.2.
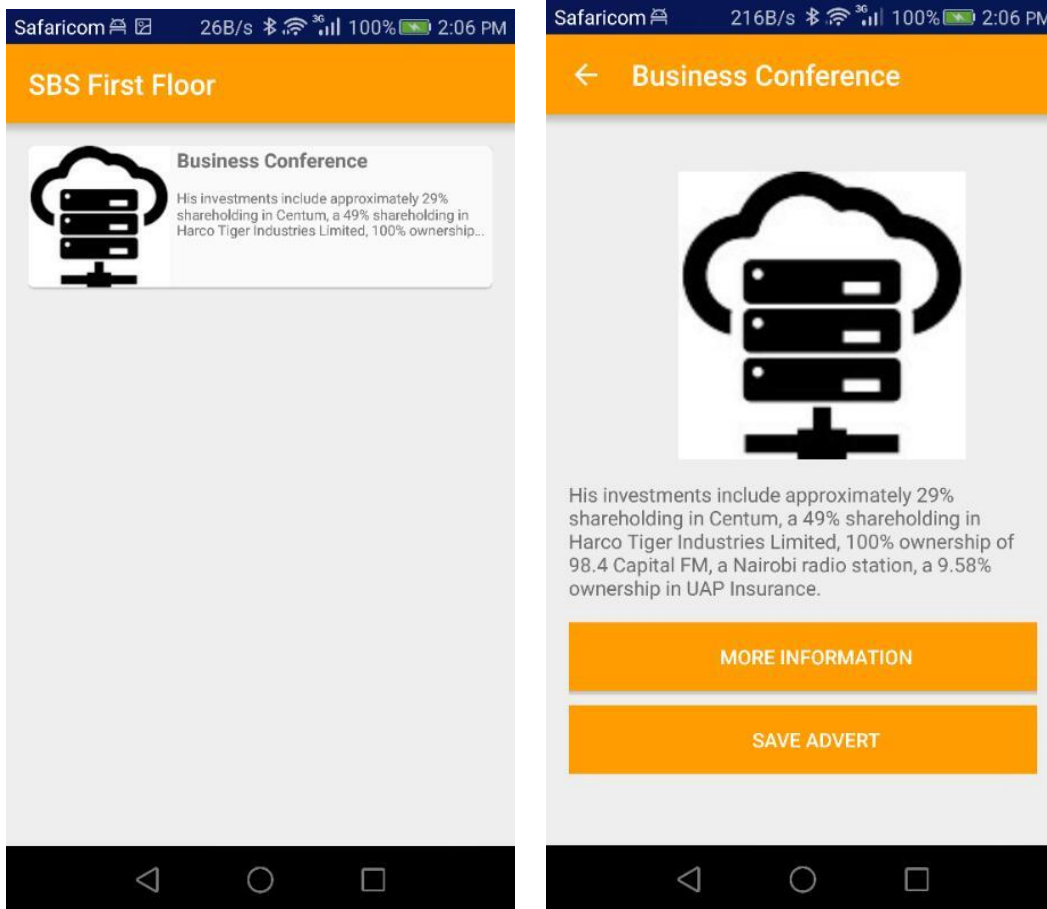
Figure 5.2: User Dashboard

5.2.2 Web Back-End

The web back end was developed for use by the administrator, enabling them to add, remove and modify locations, beacons and advertisements. It was developed in Java EE backed up with MySQL database holding user data. Figure 5.3 shows the administrative back-end after login is complete.
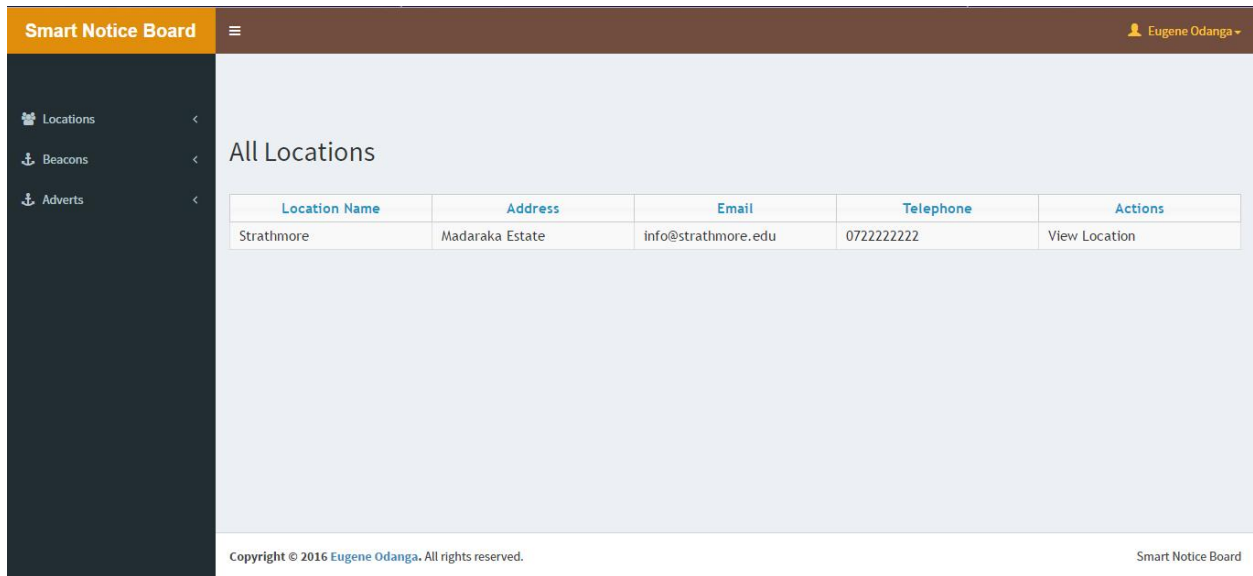
Figure 5.3: Administrator Dashboard

5.2.2.1 Add Location

The administrator can add new locations within which beacons can be placed and adverts posted. Figure 5.4 shows the user interface for adding locations.

Figure 5.4: Adding Locations

5.2.2.1 Add Beacons

The administrator can add beacons and view beacons as shown in Figure 5.5 and Figure 5.6:

Figure 5.5: Adding New Beacons

Figure 5.6: Viewing Installed Beacons

5.2.2.1 Add Adverts

The Administrator has the ability to add, remove, modify and view advertisements ad notices to beacons in locations as shown in Figures 5.7 and Figure 5.8:

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Figure 5.7: Adding New Adverts

Figure 5.8: Viewing All Adverts

5.3 System Testing

5.3.1 Introduction

This section describes tests that were conducted on the mobile and web applications against the functional and non-functional requirements of the application. During testing both the mobile and web application were considered as one system as they work together.

5.3.2 Usability Test

Usability testing was conducted to determine whether the application was user friendly. It was used to ascertain that users could navigate through and understand the applications functionality. The major things that were tested included: System flow from one window to another, visibility of icons and text and ease of understanding by the application users.

5.3.2.1 Application Installation

Figure 5.9 shows results of testing the application installation process. All respondents rated the application installation process to be excellent across the test devices.
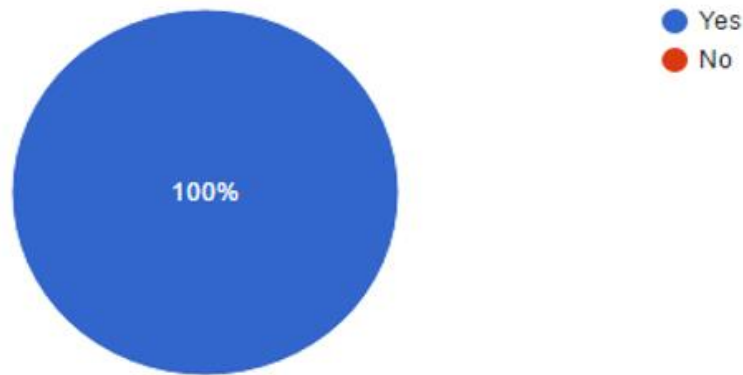
Figure 5.9: Installation of Application Test Results

5.3.2.2 Application Look and Feel

All of the respondents gave positive feedback concerning the look and feel of the application. Figure 5.10 shows the results
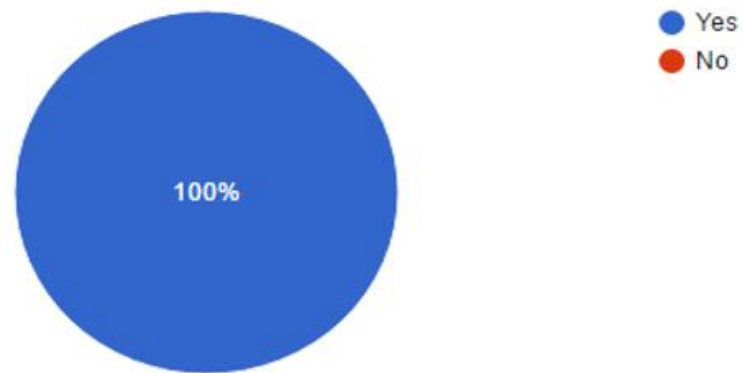
Figure 5.10: Application Look and Feel Results

5.3.2.3 Application Usability

Most of the respondents rated the application as useable as shown in Figure 5.11:
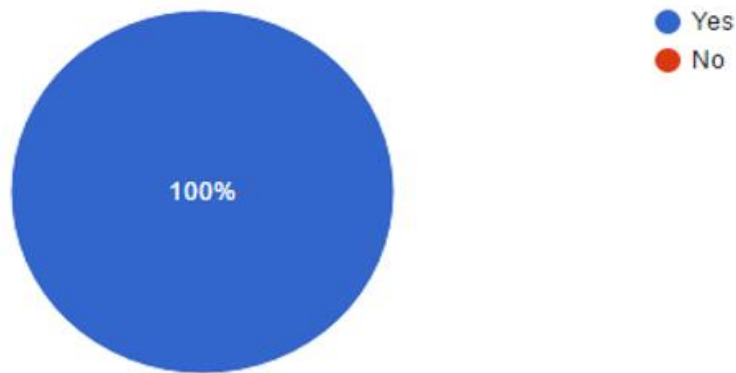
Figure 5.11: Usability Results

5.3.2.4 Finding Core Function

Most of the respondents agreed that the applications main functionality was easy to find due to its straight forward nature. Figure 5.12 shows the results:
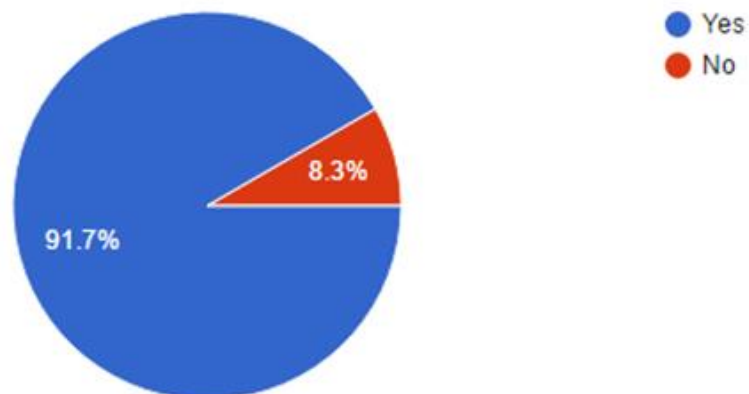
Figure 5.12: Ease of Finding Core Functions Results

5.3.2.5 Responsiveness of the Application

How responsive an application is to the users input can be a major determinant of wether or not the user will be satisfied with the experience presented. Figure 5.13 shows the results of the application responsiveness tests conducted.
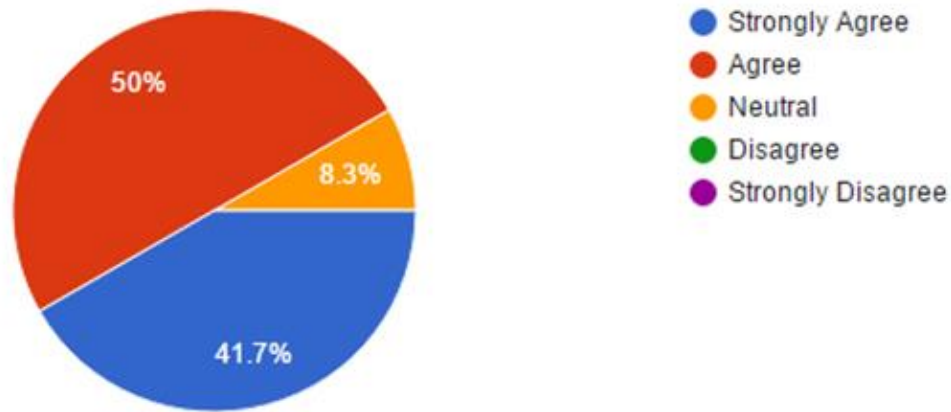
Figure 5.13: Application Responsiveness Results

5.3.3 Functional Testing

Functional tests were done based on the use cases to determine whether system implementation and design was done successfully. For each sue case testing measures were established with results either being considered successful of unsuccessful.

Table 5.1: Creating User Accounts Test Case

Identifier	1
Test Case	Create User Account
Description	User creates account using social media pages
Utilized Use Case	Registration
Results	Successful account creation and activation request sent to administrator
Pass/Fail	Pass

Table 5.2: Logging into System Test Case

Identifier	2
Test Case	Login into the system
Description	User performs login using social media accounts
Utilized Use Case	Login
Results	Successful login and access granted
Pass/Fail	Pass

Table 5.3: Viewing Available Notifications Test Case

Identifier	3
Test Case	Viewing available notifications
Description	User is able to view and interact with any available notices
Utilized Use Case	View Notices
Results	Successful connection with beacon and viewing of notifications
Pass/Fail	Pass

Table 5.4: Saving Available Notifications Test Case

Identifier	4
Test Case	Saving available notifications
Description	User successfully saves available notices to device memory
Utilized Use Case	Save Notification
Results	Successful save a notification

Pass/Fail	Pass

Table 5.5: Managing Notices Test Case

Identifier	5
Test Case	Managing Notices
Description	Administrator is able to add, remove or modify notifications
Utilized Use Case	Manage Notices
Results	Successful addition, modification or removal of notices
Pass/Fail	Pass

Table 5.6: Managing Beacons Test Case

Identifier	6
Test Case	Managing Beacons
Description	Administrator is able to activate or deactivate a beacon
Utilized Use Case	Manage Beacons
Results	Successful activate or deactivate a beacon
Pass/Fail	Pass

5.3.4 Compatibility Testing

Compatibility tests were conducted on the mobile application and the web application to ensure compatibility with available platforms. The mobile application was tested against the relevant available Android platforms while the web back-end was tested against available browsers.

5.3.4.1 Android Platform Compatibility Testing

Compatibility tests done for the Android platform were conducted as shown in Table 5.7:

Table 5.7: Android Platform Compatibility Test

Android Platform	API Level	Compatibility
Android 4.1.X (Jelly Bean)	16	Yes
Android 4.2.X (Jelly Bean)	17	Yes
Android 4.3.X (Jelly Bean)	18	Yes
Android 4.4 - 4.4.4 (KitKat)	19	Yes
Android 5.1 (lollipop)	21	Yes
Android 6.0 (Marshmallow)	23	Yes

5.3.4.2 Web Back-end Testing

Table 5.8: Web Back-end Compatibility

Browser Type	Compatibility
Internet Explorer (versions 4 and above)	Yes
Firefox (version 8.0 and above)	Yes
Chrome (All versions)	Yes

5.4 Validation

Validation was done in order to ascertain that the application indeed addressed the challenges that were faced in terms of context aware notification. A questionnaire (In Appendix C) was designed and distributed among end users to test the applicability of the designed mobile application in providing context aware information. 90% of the respondents were students currently pursuing

various degrees in Strathmore with the remaining 10% consisting of former students and staff at Strathmore University. Figure 5.14 shows a visual representation of the results:
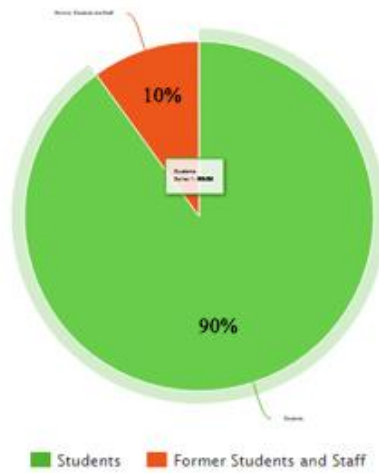
Figure 5.14: Demographics of Respondents

The respondents were asked if the mobile application presented to them fully solved some of the challenges presented by the systems currently in place. 80% of the respondents said that it did with 20% saying that it partially solved the challenges. This is shown in Figure 5.15:
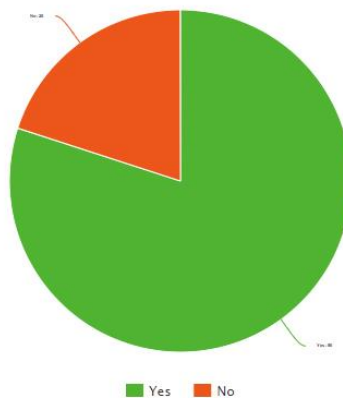
Figure 5.15: Responses to the Question of Whether the Application Solved the Present Challenges

Of the sample population, the respondents who answered yes to the question of whether or not the current system solved the challenges presented by existing features, were asked to further state some of the main features that the mobile application had that could solve the available challenges. The most outstanding feature according to the feedback was the context awareness that allowed users to interact with posts and advertisement only when in the correct context. This meant that

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users could only interact with advertisements and posts only when the posts were most actionable. It also meant that once a user was done with the interaction and were outside of the correct context they did not have to interact with it again, essentially reducing spamming.

Another functionality that users pointed out was the ability to save posts to their mobile devices for future references. This feature allowed users to be able to keep what was relevant to them for future use or even sharing. This feature was also coupled with the ability to get links for more information beyond just the post, essentially making it extremely helpful.

The respondents were asked to indicate whether they were satisfied with the solutions provided by the mobile application for solving problems in the lack of context in noticeboard posts. 60% of them expressed their satisfaction with the solutions put for by the application as shown in Figure 5.16:
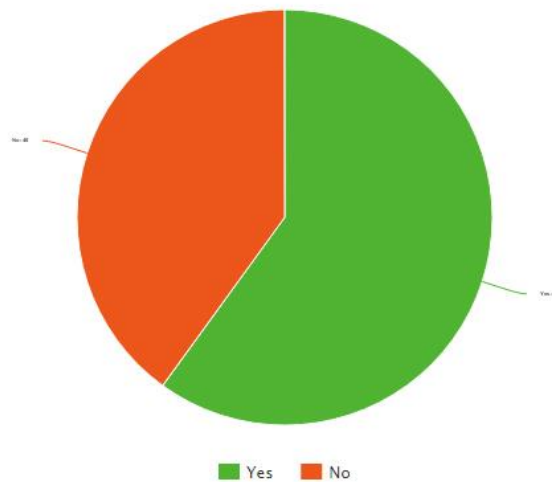
Figure 5.16: User Satisfaction on the Functionalities of the Mobile Application.

Finally the respondents asked if they would recommend the mobile application be implemented in institutions of learning and malls across the country. A resounding 100% of them responded with a yes, showing their confidence in the applicability of the developed mobile application in providing context aware advertising to institutions of learning and malls.
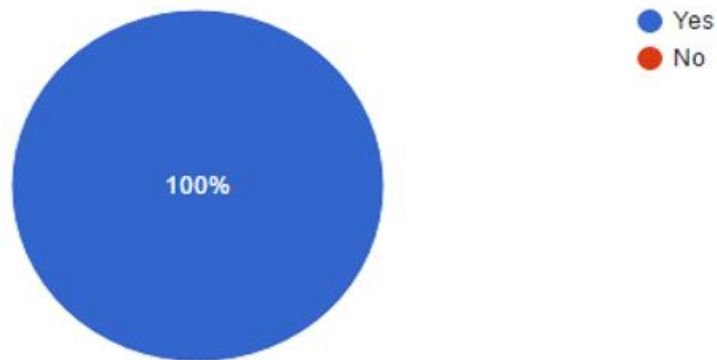
Figure 5.17: Respondents Recommendation of the Smart Noticeboard for Adoption.

5.5 Conclusion

The system requirements developed in the system gathering and analysis phase provided fundamental information that was used in the development of the application. The system design phase provided information on how the system was developed. The research questions and objectives were also put into high consideration to ensure that the system was implemented along the lines of the user requirements provided by potential users. The overall development was done in adherence to the proposed objectives.

Chapter 6 : Discussion of Results

6.1 Introduction

The purpose of this research was to identify the challenges faced in information dissemination in institutions of higher learning, to investigate the techniques and technologies used in achieving context awareness, to design, develop and test a smart noticeboard application powered by context aware services and BLE and to validate that the smart noticeboard mobile application solves some of the challenges faced using some of the current methods currently employed in information dissemination in institutions of higher learning.

This was done with the aim of identification and development of an alternative suitable technique that will be used to solve some of the challenges faced in information dissemination. The findings of the research aided in the identification of the appropriate technique and development of a mobile application and a web based back end system. By providing the smart noticeboard mobile application, information dissemination in institutions of higher learning was made more advanced, easier to use, effective and efficient.

The mobile application was developed for use by students with access to mobile data and data enabled phones, with Bluetooth Low Energy capabilities and running Android 4.0 and above. The web based back-end was developed for use by management and an administrator, accessible via an Internet enabled standalone computer, laptop or mobile device. This section looks into the findings and achievements of this research, how the objectives were obtained and met and provides a review of the developed application looking at some of the advantages and disadvantages of the system.

6.2 Explanation of the Findings

This study had one questionnaire which was handed out and interviews conducted on respondents to validate the usability of the developed mobile application relative to the current information dissemination systems. The interviews were used to understand how the current systems work, their limitations and to get an opinion on the nature of the system that was to be built.

6.3 Discussion

This section discusses step by step how the objectives of this research were met. The first objective in section 1.3 was to determine the factors that lead to poor information dissemination in institutions of higher learning. The study shows that there are several challenges that are faced by institutions of higher learning when it comes to information dissemination. These challenges are explained in detail in section 2.2. The various shortfalls in the currently available channels of communication have been adversely sited as being one of the main challenges faced by institutions of learning in information dissemination to students. These channels which include email, websites, social media, static noticeboards and campus radio are seen to have major pitfalls which eventually lead to the people who are meant to receive these messages not getting them or out rightly ignoring them.

From the one on one interviews conducted most of the respondents showed concern over the growing amounts of consumable content, all of which is relevant to some group of people but irrelevant to the vast majority. This spam content is one of the factors that has been noted to cause students not to receive messages through multiple channels. The challenges noted contributed to the development of a platform that took into account all these shortfalls and the approach discussed. These challenges addresses most of the generic issues faced by institutions of learning in information dissemination.

The second objective was to analyse the current techniques and technologies used in context aware information dissemination. This helped us understand the technologies that are currently in place used to promote context awareness and to look at solutions that have been deployed in real life environments that use the same principles and technologies. It discusses their strengths and weaknesses, looking at gaps that can be exploited to make the developed mobile application better. The major technology discussed is BLE Beacons, which are small radio transmitters that broadcast their identities to nearby smart devices, enabling them to trigger certain functions whenever they are in their proximity. Other less used technologies were also identified, discussing their roles in promoting context awareness for smart devices, their strengths and weaknesses.

The third objective was to design, develop and test a mobile application using the power of context awareness in information dissemination. Section 2.4 discusses the various frameworks and gives a detailed description of how the proposed implementation would work. The development methodology is further discusses in section 3.2. The application was developed with the main advantages being discussed in section 6.4. The main objective of this section was to design and develop a smart noticeboard using context aware services. Section 4.4 details how the application was designed putting into account user requirements and overall objectives. The application was tested with questionnaires being handed out to them. The results are shown in section 5.3.

The last objective was to validate the application ensuring that the application works as intended and solves the need of the intended users. The developer did multiple tests including functionality tests whose results are shown in Section 5.3.1. The users were also given the application to test with the results being shown in section 5.3.2. From the findings, it was concluded that the applications functionality worked as required and any corrections or errors found were rectified.

6.4 Advantages of the Application Relative to Current Systems

The application was compared to systems currently in use and the following are the advantages that were found:

I.   Users did not have to crowd in front of noticeboards to receive notices and advertisement. There was a wider range of reach with the BLE Beacons and the mobile application.

II.   Users were able to save notifications onto their mobile devices without having to take pictures of the notices improving share ability and content quality.

III.   Users were able to act faster to notifications due to their placement, essentially making them more actionable. Notices were only displayed when users were close to the source of the information.

IV.   Users did not have to be spammed with information on their mobile devices once outside of the beacons range. Loss of context means loss of information.

V.   The application provided administrators with a back end to manage notifications and general content, locations and beacons.

6.5 Limitations of the Mobile Application

The limitations of the application include the following:

I. The application is limited to smart devices running Android 4.0 and above and have Bluetooth Low Energy enabled.

II. Both the mobile application and the web back end require Internet access to be able to work.

Chapter 7 : Conclusion, Recommendations and Future Work

7.1 Conclusion

This study reviewed information on information dissemination needs and shortfalls in institutions of higher learning and techniques and technologies use in achieving context awareness for smart devices. From the analysis conducted, the results pointed out that there were major shortfalls in the information dissemination channels and methods in universities.

The results lead to the development of a smart noticeboard mobile application and administrative back-end using the power of context aware services using Bluetooth Low Energy Beacons. The key features of the application include the ability to receive notices directly on smart devices when in the correct context, the ability to save notifications onto user devices and ease of notification management through the administrative back end. The application was aimed at the fast, easy and efficient retrieval of notifications and advertisement in the correct and most actionable contexts. It reduces spamming and improves the action ability of notifications and adverts by placing them as close as possible to the notice sources. System tests were conducted ensuring that the application performed, looked and felt, ease of use and system functionality were at acceptable levels.

7.2 Recommendations

Context aware computing and the Internet of Things are at the centre of future advancements. Trying to find out the easiest way to connect everything to everything in daily life has become a priority for researchers across the world. In the same line, I would recommend that the Institutions of higher learning be the first to implement context aware services for different functions notification and advertising to payment. The smart noticeboard application should be a gateway to more services being hinged on BLE and context awareness. Secondly, it is imperative that institutions do away with some of the older communication methods in favour of solutions that utilize smart phones.

7.3 Future Work

The limitations of this system implemented in this research have recommended the following areas as recommendations for further work:

I. The application should accommodate alternative sources of context awareness including the use of Wireless networks as a substitute for Bluetooth.

II. The application should be developed for mobile multiple platforms allowing users with other devices to be able to access services.

III. The system should include push notifications directly to user devices notifying them when they are in a beacon ready environment so that they do not have to open the application directly.

IV. The system should also include notification duration timeouts to further automate the process.

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Appendices

Appendix A: User Questionnaire

User Questionnaire

1. What kind of mobile device do you currently use?
   - Smart Phone
   - Feature Phone

2. What operating system is your mobile device running?
   - Android
   - IOS
   - Windows
   - Other

3. If you have an Android Device, what version of Android are you running?
   - Android 6 (Marshmellow)
   - Android 5 (Lollipop)
   - Android 4 (Kitkat)
   - Android 3 and below

4. What is your main source of 'campus essential' information on campus?
   - Email
   - Social Media
   - Noticeboards
   - Campus Website

5. What challenges do you face with using the above modes of communication?
   - I receive a lot of information that is not relevant to me (Spam)
   - The information I receive is ambiguous or unclear
   - The information received is often not actionable
   - I receive outdated information
   - Other

6. How often do you stop to view information on a noticeboard?
   - Hourly
   - Daily

- o Weekly
- o Monthly
- o Never

7. Do you ever act on the notices that you view on these boards?
   - o Yes
   - o No

8. Do you think notices would be easier to act on if you could view and store them on your mobile device?
   - o Yes
   - o No

9. Would spamming be reduced if you could only receive notices only when in the most relevant and actionable context?
   - o Yes
   - o No

Appendix B: Test Questionnaire

1. Did you manage to carry out the following tasks?

    a. Create an account?

        o Yes

        o No

    b. Access the contents of a beacons?

        o Yes

        o No

    c. View More details about an advert?

        o Yes

        o No

    d. Save an advert to your phone storage?

        o Yes

        o No

2. Did you have any difficulties downloading the application?

        o Yes

        o No

3. If you had difficulties, please list them

4. Did the application install correctly?

        o Yes

        o No

5. If you had difficulties, please list them

6. Did you like the look and feel of the application?

        o Yes

        o No

7. If not, please list the reasons.

8. How would you gauge ease of use of the application, 1 being hard and 5 being easy?

        o 1

        o 2

        o 3

        o 4

     ○ 5

9. Does the functionality meet user requirements?

     ○ Yes

     ○ No

Appendix C: Turnitin Report