Mobile Campus Navigation Application with Augmented Reality

Group Number: 20

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August 2014
DECLARATION

We do hereby declare that the work reported in this report was exclusively carried out by us under the supervision of (Name of the supervisor). It does not contain any material previously published or written by another person or our self and only it describes the results of our own independent work except where due reference has been made in the text.

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Abstract

Most of technologies of today’s world, which are enriched with various powerful features and amazing quality characteristics, enables software developers to come up with best possible software solutions, no matter what the context of the particular issue. Technologies such as Augmented Reality (AR), is utilized almost every kind of fields in today’s society.

As computers become more advanced through mobile devices and wearable technology, augmented reality will become a seamless experience that is a part of our everyday lives. In the context of this work a mobile navigation application for the University of Colombo is developed enabling the user to find specific locations on campus and offers him/her the ability to explore the campus environment via AR. Furthermore the system, Mobile Campus Navigation with Augmented Reality (MCNAAR) application is capable of giving guidance in both outdoor and indoor location navigating and retrieving details of campus officials and lecturers.

With the proposed system it is expected to serve as a useful and informative navigate helper for both students of University of Colombo and for the visitors, at indoor and outdoor locations and to use as an application to check officials and lecturer availability and retrieve detail about them when they are not available at the office at any time.

The ‘Mobile Campus Navigation Application’ has been developed according to the RUP (Rational Unified Process) model which supports Object Oriented Analysis and Design concepts. The system made in android platform and based on Model-View-Controller (MVC) architecture concepts. Android was chosen as the development technology with the support of open source web frameworks, which makes the system highly reliable, maintainable and user-friendly. MySQL was used as the Relational Database Management System and Apache server was selected as the Application Server. In addition to them, Unified Modelling Language (UML) was used for analysis and design.
Acknowledgements

We take this opportunity to express our gratitude to everyone who helped us and guided us to complete the project successfully.

First of all we are so much grateful to Prof. K.P. Hewagamage, the coordinator sir of SCS 3016 group project course, for the valuable effort made through during this course, in order to achieve us a great experience of outcome a successful software project at the end. For the support he had given towards the success of this project and for giving us the domain knowledge and providing necessary information and documents regarding the project.

We wish to express our gratitude to our project supervisor sir Mr. K.P.M.K. Silva lecturer at UCSC, who gave constant supervision despite his busy schedule, for the technical guidance provided to move us in correct path, truly for the patience he had when working with our team, and without whom it would not be a success.

University Of Colombo School Of Computing and its panel of dedicated lecturers would be acknowledged our thankfulness for the knowledge and the wisdom we have gathered while being students in there.

We are also grateful to our family and friends, for supporting and encouraging us to complete this project successfully.

Finally we would like to thank all the colleagues at UCSC who have been with us in all difficult times with suggestions and supportive words which carry us to make this project a reality.
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<tr>
<td>API</td>
<td>Application programming interface</td>
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<tr>
<td>AR</td>
<td>Augmented Reality</td>
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<tr>
<td>DB</td>
<td>Data Base</td>
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<tr>
<td>E-mail</td>
<td>Electronic Mail</td>
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<td>GHz</td>
<td>Giga Hertz</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>HTTP</td>
<td>Hypertext Transfer Protocol</td>
</tr>
<tr>
<td>LLA</td>
<td>Latitude, longitude, altitude</td>
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<tr>
<td>MB</td>
<td>Mega Bytes</td>
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<tr>
<td>MCNAAR</td>
<td>Mobile Campus Navigation Application with Augmented Reality</td>
</tr>
<tr>
<td>MVC</td>
<td>Model-View-Controller</td>
</tr>
<tr>
<td>No</td>
<td>Number</td>
</tr>
<tr>
<td>POI</td>
<td>Position of Interest</td>
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<tr>
<td>QR</td>
<td>Quick Response</td>
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<tr>
<td>RAD</td>
<td>Rapid Application Development</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory</td>
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<tr>
<td>SDK</td>
<td>Software Development Kit</td>
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<tr>
<td>VR</td>
<td>Virtual Reality</td>
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Chapter 1 – Introduction

1.1 INTRODUCTION

Mobile phones are nowadays far more than merely devices to communicate based on new techniques like GPS and sensors, compass and accelerometer, that can determine the orientation of the device. Location-based applications coupled with augmented reality views are possible. In the context of this work a mobile navigation application for the University of Colombo is developed enabling the user to find specific locations on campus and offers him the ability to explore the campus environment via augmented reality.

1.2 Goals and Objectives

1.2.1 Goal

The main purpose of this system - Mobile Campus Navigation Application with Augmented Reality - is to give a mobile based solution, mainly for handling matters related to students and visitors when travelling around the campus premises, in a manageable way to reduce the wastage of time, dissatisfaction and to gain efficiency, accuracy, application friendliness, speed, and plausibility of the application to the small campus environment. And also to get the maximum satisfaction from the users, both students and non-students (visitors), by providing a quality and standardized service.

1.2.2 Objectives

1. Provide a useful, informative, mobile based solution for campus navigation inside UOC, which will contain all the necessary details, in order to ensure easy, accurate navigation and identification of various buildings, departments and
help the students and visitors to reach their desired locations without any inconvenience.

2. Implement a special mechanism using QR codes to avoid inconveniences caused due to unavailability of campus officials (lecturers, department heads etc.)

3. Provide transport information of accessible bus routes when a user wants to go outside the university.

4. Provide an efficient way to determine indoor positions by using a special indoor location tracking method when GPS signals become weak.

1.3 Scope

The scope of the project is determined by the allocated time, resources and the client’s requirements. The scope of the system is limited and can expand in a modularized manner. Presently the system covers only the University of Colombo premises. The scope of the proposed Navigation Application System can be summarized as follows;

Location Tracking Module

- Outdoor location navigating
- Indoor location navigating

Users can navigate through the campus via guidance given by the AR browser. They can browse buildings, locations etc. or search for locations. For different situations that occurs while navigating on campus, there should be separate views (AR view, Map view, List view) of navigation guidance given through the system.

Lecturer Availability Checking Module

Provide information about a particular official (ex: Lecturer) at the university when he/she is unavailable at the office. Officials are capable of adding, modifying, removing their personnel details, daily schedule including timetable, and details about meetings etc. whenever required.
Transport information Module

User guidance system for obtain transport details such as bus and bus routes.

1.4 Overview of the Dissertation

The remaining chapters present different aspects of the system along with relevant figures and tables describing how the work carried out. After the Introduction chapter which describes the motivation for the project with the scope and objectives, the dissertation contains five main chapters as described below.

Chapter 2 - Analysis: This chapter explains about the requirements gathering techniques and collected functional, non-functional requirements to design and develop the system.
Chapter 3 - Design: The chapter defines the design methodologies of the system, tools and techniques employed in the designing phase and the database design. This chapter also includes detailed Use-Case diagrams and narratives and GUIs.

Chapter 4 – Implementation: This chapter describes the development procedures of the system. Further, the implementation environment, software tools and technologies used at the time of development are explained.

Chapter 5 – Evaluation: This chapter defines how the system was tested using sample data and the outcomes of the assessment. This includes testing procedures and test cases.

Chapter 6 - Conclusion: This includes the critical evaluation of the project and gives details about the recommended future improvements and lessons learnt.

1.5 Chapter Summary

This chapter explained the introduction to the proposed Mobile Campus Navigation Application System, main goals and objectives which are supposed to be achieved by implementing this system and the project scope in detail. In the next chapter, an analysis of similar systems will be presented.
Chapter 2 – Similar Systems

2.1 Introduction

The purpose of this chapter is to give a detailed idea about what are similar systems that resides in the content of the application that this report specified for. Here mentioned are few of related products and applications that is been delivered in the content of mobile campus navigation area. All of them are been compared are reviewed individually in order to distinguish the properties of “Mobile Campus Navigation with Augmented Reality” with other products.

The given below are mentioned again the functionalities of our application is for a quick recap for the comparison of the related similar systems.

1. Location Tracking Module
   1.1.1 Outdoor location navigating
   1.1.2 Indoor location navigating
2. Lecturer Availability Checking Module
3. Location Based Route information Module

2.2 Similar system analysis

2.2.1 Arizona Mobile

Arizona Mobile is the first official app and one-touch experience for all things for University of Arizona including a navigation system. Not only does Arizona Mobile make life easier for current students, but past/present students around the world can stay up to date with features like event calendars and video tours that make every user feel like they’re on campus – no matter where they are. [13]
Features
Some of the main features included in this system are Maps, Phonebook and campus directory, Course listings, UAccess Student, UAnews, Event listings, Social Media, Videos, Library, Tours, Photos, Alumni, Emergency contacts.[12]

Review and Comparison
Comparing to MCNAAR system there are few unique features resides with this mobile application. For example the users’ social interaction function is a new addiction. Pupils could be in updated with collage news and headlines via this system. But there are no such functions that implemented in this system as it for MCNAAR system provide the user with. The map is not well working with upper versions of Android mobiles because there are less utility and information given. Would suggest to integrate University Access into the app rather than directing to a browser for the mobile site.
2.2.2 Oregon State University Mobile

The application comes in both iPhone version and Android supportive platforms. The description for the application system developed by the University of Oregon is as described below.

Features

- Offers an optimized experience for a variety of web phones and devices.
- Can access this site from any mobile web browser, with real-time data.
- Can find buildings on campus or track down phone numbers just using your thumb: the auto-populating people finder will even complete user typing, saving time in a crunch.

Review and Comparison

It is more of iOS rather than Android. Still uses outdated iOS UI elements. Quick functionality of finding buildings and phone numbers. Could work on the add contacts. Would add the email to the wrong contact on user phone. If could link towards the online services, this app would be phenomenal. Would be able to check class schedules, add/drop courses, etc. Many of MCNAAR application features are not much similar with this system, only a partial of properties are being met with compared to MCNAAR application software.

Figure 2.3: User interfaces of OSU system
2.2.3 MIT Campus Navigation Tool

Features
- Anyone who has visited MIT knows that precise directions are key to avoid getting lost, and the new campus map made things like a trek breeze.
- The map even tracked MIT shuttle buses in real time and could send an alert when one approached. [14]

![Figure 2.4: User interfaces of MIT system](image)

Review and Comparison
It’s a high technology based system which facilitates the students at MIT. Only the function of outdoor mapping is being met there compared to MCNAAR applications features. And the disadvantage is that this application is only been developed targeting iPhone users, because of vast user percentage for Android users.

2.2.4 University of Michigan Mobile

This android application is developed by the University of Michigan to facilitate its students in various ways. Giving the students and users’ benefit of navigating themselves in the University.
Figure 2.5: User interfaces of Michigan Mobile

Features
- Campus Map - Find locations, parking, and directions across campus.
- Computer Labs - Locate an open seat at campus computer labs.
- CTools - Check your course and project sites on the go. View grades, access resources, read announcements, and more.
- M-Bus - View a map of U-M bus routes, search for a stop, and find out when the next bus will arrive. The map is animated in real-time to show the buses progress to each stop.
- Academics - View your current class schedule, set up grade alerts, and find classes.
- Directory - Search MCommunity, the university online directory, for students, faculty, and staff. Automatically add new contacts to your phone.
- Events - Find out what’s happening around campus, from concerts to symposiums.
- Feedback - Submit questions and comments about the Michigan App.
- Emergency Contacts - Get local police and nearby medical care phone numbers.

Review and Comparison
Good application to be used, but the design is bad. Grade alerts functions are working well. Map function is very much helpful and very well managed in the application. But the search for an event is cumbersome because user need to select the category for each
event on a particular day making it not so time efficient rather it would be easy if all of them event are shown in a single view. The application’s functions are fine, but the design is very dated. User can’t use it in a new version of android phone properly. It need to be updated according to the current Android design guidelines. [11]

Although it has many features, kind of like all in one with more general needs been delivered by the system.

2.2.5 WVU's Augmented Reality Campus Map

West Virginia University campus, let the their user’s to pull out their iPhone or Android-based phone, point it at the building, and the app they’ve downloaded called Layer Reality Browser tell whether the building is the site of user very first class. WVU’s use of an augmented reality-enhanced campus map is one of the many ways the university is staying on the cutting edge of the mobile technology wave. The Web unit of WVU’s University Relations department has enabled the WVU community to check how many computers are available for use on which floor of a university library or the status of the Personal Rapid Transit system using a mobile-friendly format. Prospective students can even check their application status via text. These developments in mobile technology aren’t just the leading edge for higher education.

![Figure 2.6: User interfaces of WVU AR map](image)
Review and Comparison

The WVU’s mobile application delivers a sufficient way to get the details of a particular location within the University. It has the features that are user-friendly, but the thing is MCNAAR uses the same technology to track down a location of interest additionally using Augmented Reality techniques to enhance the user interaction and satisfaction. Although this system provides navigating module, it’s the only function that not resides different with compared to MCNAAR which had been proposed and developed with many of the features.

2.2.6 AR Navi

AR Navi is an Android application that helps anyone new to the Faculty of Engineering in National University of Singapore to navigate to the different locations in the faculty, and to get acquainted with the various facilities, offices, and places of interest that can be found throughout the faculty.

![User interfaces of AR Navi](image)

*Figure 2.7: User interfaces of AR Navi*

This is the main interface of the application. The 3D map which is overlaid on the camera view is displayed according to the direction the user facing at. The red arrow on the map shows user’s current location and the direction him/her facing in the map, and will be updated as user walk around campus. Individual buildings on the map can be tapped on the touch-screen to bring up places of interest in those buildings. Specially-designed markers have been placed at various locations. By pointing the mobile device
at a marker to fix current location, and could discover interesting facts about user’s current location.

**Review and Comparison**

All Android 2.1, 2.2, and 2.3 devices with camera, GPS, accelerometer, magnetic sensor, and Internet should be able to run this application. As it for MCNAAR application there is a similar technology been used to navigate outdoor locations and for indoor locations and buildings, it uses LLA markers with 2D Maps. And also static map function is too being used and given to the user to notify his/her awareness about the area the user currently at. Another important module of MCNAAR application is its capability to serve official’s information using qr code scanning to users. Inspite of being just a navigate helper, this system provides useful information about lectures/officers in the campus. Some devices running on old hardware may not work. Only this function is been delivered to the user by this system, but in MCNAAR case there are more properties to the user to be interact with.

**2.3 Chapter Summery**

This chapter presented some important facts about systems which have a similarity with the context of MACNAAR application. Important features of those similar systems were discussed along with the analysis of strengths and weaknesses of those features. When implementing this mobile campus navigation system, this similar system analysis helped us a great deal in order to empower our system with existing and newly introduced functionalities.
Chapter 3 - System Analysis and Design

3.1 Introduction

Analysis is very important procedure for a project’s success. Therefore significant amount of time and effort were put in this segment. The main processes of this phase include domain understanding, requirements collection, classification, structuring, prioritization and validation. Suitable collective methods and procedures were engaged to carry out the analysis phase in an effective way. [1]

System design phase is an iterative process in which requirements gathered in analysis are translated into a “blue print” for constructing the system. At first, the blue print depicts a high level abstract view of the system. Afterwards this can be elaborated into detailed functional behavioral requirements. The lower level abstractions are achieved through design interactions and continuous enhancements. Software design phase accompanies an architecture diagram with pointers to detailed feature specification of smaller pieces of the design. A design is a stable reference, outlining all parts of the software and how they will work. [3]

3.2 Requirement gathering and analysis

3.2.1 Fact Finding Methods

This is the most important phase to implement a high quality application. As it is given many information about what user really want and what are the requirements of the user. If the requirements are correctly gathered, then the system can be correctly implemented.

There are many techniques that can be gathered facts, in formal methods as well as informal methods. Some examples for the fact finding techniques are close-ended interview, open-ended interview, observation, document review, surveys and scenarios.
It was very helpful to conduct open ended interviews as the members who participated to it is free to express his/her ideas without any affect. Survey is the other very important fact finding method, as participant get 15 MCQ paper to answer on it. It is very helpful to developers as requirements can be directly identified and can be included questions that talks the specific requirements is needed or not.

The captured facts were represented as scenarios and use case diagrams to give a clear picture on basic requirements and interaction sessions of the system, which can be understood by both technical and non-technical functions.

### 3.2.2 Analysis existing systems

It is useful to discover the existing systems and traditional methods in order to develop a new system. Some of the current systems are expensive to maintain and do not fulfil what the user really want. There was not 100% fulfilled system currently. Most of them are not fit enough with user requirements. Here are some traditional manual systems that are currently exists.

- Displaying a map covering the whole campus at the entrance.
- Showing arrows as directions.
- Naming departments and pasting banners inside the building.

**Displaying a map covering the whole campus at the entrance**

In front of the entrance, there is big campus plan to find ways to university visitors. It is very hard to keep the path in memory. Most of the places are currently changed and some of them are presently not existing. So the information of the map is not far enough to find the destination. As the result of renovation of the department, some buildings are removed, or some of them are changed with other department. So the map is static, it is impossible to change. If it is, it would very expensive or sometimes it is beneficial to create new map rather than updating the existing one.
Showing arrows as directions

There are banners and arrows that directing the user saying the correct path. Sometime it is easier to go in other way rather than keeping focus with the arrows. Problem is it is not a long term solution to find out the buildings, because of some arrows may get old and ruined, some are fallen down. So they are not certify the stability. On the other hand it is effected to environmental pollution and it ruins the beauty of the natural environment.

Naming departments and pasting banners inside the building

Buildings are named by pasting banners on the walls. If the user is far away from the building, the banner in the wall cannot be seen by the new comer. Those banners are not a solution for long tern period. As they faces to rain and get damaged.

3.2.3 Functional Requirements

3.2.3.1 Outdoor navigation of places inside the university

System shall identify the building or places which are being searched. Details of the locations, event details and description of buildings and other important places of the university are stored in the database. Once the user enter the place where he/ she wants to visit or points the camera to the desired location, system finds the related data and the data are displayed on the screen in user friendly way. If the input data of the user is invalid, system should suggest related data or display some message that the data are not in the database. There are three main components of the outdoor navigation of places inside the university separated according to the type of the view which the user can choose. [3]

Augmented view:

In this view, user shall identify the places by just pointing the camera to the desired location and by giving the radius of locations where he/she needs to go without typing anything. In the application there is a tab called augmented view and user need to tap it. Then the augmented view module is started and switch with the server and GPS
system. Then the latitude and longitude of the current location of the user is obtained by the system and the system will shows all POIs which are inside the user intended radius of location obtained through the system database. POIs are stored in the database previously by admin and using GPS, distance between the current location and POIs are calculated. The output data are displayed visually to the user by using labels. When the user taps each label, the description of the place with a photo, contact number and email of the building with events happening in future in the location which are stored in the database previously by admin will be displayed in the screen using a modal window.

**Map view:**
This view shall display the POIs with the data in a map. Inside the application, a map of university and surrounded area are created and when user enter the desired location as the input, system checks the database table and compare most suitable locations. Finally those places shall be indicated in the map.

**List view:**
If user wants to get details instead of taking directions, this list view shall be more important. Data retrieving from corresponding database table is same as using augmented view and map view. In list view, information are given as a list. It shall display the information in the database for every matching keywords entered by the user.

### 3.2.3.2 Finding the officials

**User phase:**
User shall be able to find out the lecturers’ or officials’ available time slots, the place where him/her currently in with the contact details (email address and contact number). QR codes are used for this module. All officials’ room doors are pasted a QR code that is generated using QR generators. QR codes of different rooms are different from each other. Thus it contained unique value and that value is used as primary key for its table. Once the user scan the QR code, the system identify its value using QR scanner in the system and then send the unique identifier stored in the QR code to query the corresponding database table to retrieve data. All data related to a specific QR code is displayed in a user friendly manner.
If the QR code cannot be read by the QR scanner due to some damage happened to the QR code sticker pasted in the door, user shall get a message displaying that code cannot be read. In such a situation, user can enter the name of the official as an input to the system and then the system will display all the details of the lecturers which matches the database table according to the input field of user.

**Officials’ phase:**
Officials shall update the details of himself/herself through the system. They have to log into the system first. Login button is linked to a login page and they shall log in by entering username and password. Entered username and the encrypted password is compared with the records stored in the database. Then the queries are run according to the user prefers to update tables. The user entered data is validated before querying with the database and if user enters invalid data the system should give warnings and shall not be processed further with the database.

### 3.2.3.3 Finding locations inside the buildings when GPS signals are weak

The system also gives the facility to navigate inside the buildings. GPS signals are weak or may not be accurate inside the buildings. Thus normal GPS system used in the outdoor navigation system cannot be used in here.

Further user can also get 2D map view inside the building. Location inside the building can be searched and the location is shown as 2D or list depending on user prefers. Therefore the system provides the confidence to the user since both indoor and outdoor navigation can be used in any situation.

### 3.2.3.4 Navigate with Google Maps

Once the user selects a particular bus route he/she is provided with an option to navigate with Google Maps. Users can preview their bus route in the map and can also view the location of their own. This option is important in seeing the current position of the journey and planning the transition of busses along the way.
3.2.4 Non-Functional Requirements

Non-functional requirements specify the important properties and constraints that the system should possess, in order to provide an optimal performance. No n-functional requirements as the name suggests, are the requirements which are not directly concerned with the specific functions delivered by the system. However, failing to meet non-functional system requirements may make the whole system unusable. The key non-functional requirements that the system should attain is given below. [2]

3.2.4.1 Performance

- Response Time
  The output should be generated within a maximum of 10 seconds depending on the internet connection speed and peak hours of the Internet usage.

- Transactions per second
  The database can handle 15 transactions per second

- Capacity
  System can serve 200 users simultaneously.

- Resource Utilization
  The application utilizes minimum amount of CPU and memory of the device.

3.2.4.2 Reliability

System should provide the correct positions. Every main buildings can be found without putting users any inconveniences. System shall work with every kinds of phones which operates the Android 2.3 version or above. If the system faced to an unusual situations, it may recover the system itself rather than giving negative performance.

In a case of failure system should be able to recover within 1 day or so depending on the type of damage (Mean time to recover should be less than one) user can manually restart the application if the system gets confused. But user may not need to do it as the
system has contained error handling or if it is fail to correct the error, the system may restarted to previous worked situation itself.

### 3.2.4.3 Availability

The server should be available 24/7/365 standby to serve user requests except the time of maintenance or upgrade.

### 3.2.4.4 Usability

- **Simple, Graphical User interface**
  The user interface is designed to be simple to use with graphical elements. Texts are simple, clear and readable. Colors are used according to a theme which makes it more usable.

- **Minimal surprise**
  Interface is designed considering the user experience of using android application with providing minimal surprise.

- **Ease of use**
  Full screen is used with right size buttons to suit big fingers. Easy navigation among windows and menus. Users can switch their prefer modes such as map view, list view and route details.

- **User Guidance**
  Users are provided with a small help guide and tool tips.

### 3.2.4.5 Accuracy

The output should be accurate to the best possible percentage and should avoid conflicting and misleading outputs when the inputs are confusing. (Minimum defect rate) i.e. critical bugs have to be eliminated.

### 3.2.4.6 Portability

All users who has a smart phone with android 2.3 version or above, GPS tracker and other main features can use the system.
3.2.4.7 Security

Officials have log in page to update or change their details. To do that they must enter username and password but they cannot change other data. Database with details of officials is independent from other databases. All data are stored in different databases and admin keeps backup for every. So if system crashed or get damaged, it can restore soon.

While using the application user do not need to give their information. Every user is independent from each other. Some buildings or places/rooms may not show as they are prohibited to give information, so the entering to the places like that is avoided and user is not able to find out without getting permission from authors.

3.2.4.8 Maintainability

System is a summation of simple modules that focuses to specific task. So the updating or editing is easy rather than studying the whole parts. It may not necessary to change the complete system in the future, because most of the modules are not directly depend on with the phone and higher versions of androids and others. Once an error is found, it can be corrected and put on the Internet and when the user connect to the server it shall update. So the users shall not need to install the whole package again.

3.3 System Design

3.3.1 Proses Model

A Software or system process model is a description of the sequence activities carried out in an SE project, and the relative order of these activities. This methodology is followed throughout the development. Iterative process model was chosen to develop this system. This is where small portions of software are developed to uncover important issues early. RUP (Rational Unified Process) model was chosen over other models such as, waterfall model, prototyping model and RAD (Rapid Application Development) model.
**Waterfall Model**

The waterfall model derives its name as the cascading effect from one phase to the other. In the waterfall model each phase has well defined starting and end point, with identifiable deliveries to the next phase. Previous phase must be completed before the next phase starts.

**Prototyping Model**

In the prototype model, it is functionally equivalent to a component of the product. It allows the user to interact and working with the prototype of the product. It is very useful to identify the correct requirements of the client. The developmental process only continuous once the client is satisfied with the functioning of the prototype.

**Rapid Application Development (RAD)**

This is an incremental software development process model that emphasis a very short development cycle [typically 8-12 weeks]. The Rapid Application Development is a high-speed adaptation of the waterfall model, where the result of each cycles a fully functional system.

### 3.3.2 Methodology for the developed system

Rational unified process model (RUP) which uses iterative approach was chosen as the process model for Mobile Campus Navigation with Augmented Reality application. RUP is an adaptable process framework, where the elements of the processes can be changed according to the user’s needs. This mainly concentrates on risk reduction due to past failures of other projects. Since it provides a specific plan for each step of the development process, it helps prevent resources from being wasted and reduces unexpected development costs. The Rational unified process lifecycle comprises four main phases namely: Inception phase, Elaboration phase, Construction phase and Transition phase. Brief descriptions of each phase are given below.

- **Inception Phase**: Inception phase is where the business case is defined
which includes the business context of the project. Lifecycle Objective Milestone is achieved in this phase.

- **Elaboration Phase**: Elaboration phase is where problem domain analysis is conducted and architecture of the project gets its basic form. Lifecycle Architecture Milestone is reached in this phase.

- **Construction Phase**: Construction phase mainly focuses on the development of components and other features of the system being designed. Initial Capability Milestone is achieved through this phase.

- **Transition Phase**: Transition phase is where the built system is transferred to the end users and they are trained and beta testing and system validations are carried out. If all the objectives are met, the Product release Milestone is met and the development lifecycle ends.

The following Figure 3.1 shows the RUP life cycles.

![Figure 3.8: RUP life cycle](image)

### 3.3.3 Alternative Solutions

There are alternative solutions that can be implemented for the Mobile Campus Navigation System with Augmented Reality. Some of them are standalone mobile
application, combination of multiple applications to perform the functions and traditional manual way.

3.3.3.1 Software Collection

Multiple various applications can be used to implement the requirements/functions alone. Some of them are listed below.

- Indoor and outdoor navigating with Metaio/Wikitiude/Layar SDK
- Google map to get path for the destination.
- QR code reader to scan the QR codes in order to retrieve the official’s availability details.
- Other applications to get Longitude and Latitude to navigate outdoor locations.

Buying different applications for separate tasks might be expensive and there might not correctly work with other applications. They might also not address what the client exactly wanted.

Combination of different applications might be very difficult and errors and bugs would be raised. Efficiency, time to response, reliability, security and other functional requirements would be decreased due to the lack of interconnections between applications.

3.3.3.2 Traditional manual System

As usual way to guide the whole locations is displaying a plain map close to the entrance. It shows static view of buildings and paths.

So user have to remember many information according to the destination. It is very difficult to memorize and not very helpful. As the maps are static, it is very hard to change the paths/buildings that are on the map. So when the locations are changed, re-implementing the map is very expensive.
3.3.4 Reason to choose mobile android application

- Nowadays, smart mobile phones are very common and most of the people use.
- Android is most common OS for many users.
- Android is very easy to learn as it is based on java and object oriented methodology. So developing the system is very easy when comparing with others.
- Easy deployment.
- Database is in other place and the centralized architecture is used.
- User do not access database directly as it is in separate place so the security is high.
- Basic requirement that should be needed with the application such as Camera, GPS receiver compass and internet connection are included in every smart phone. And the quality, accuracy and efficiency is very high as they are in inside the smart phone.
- Easy to use an android smart phone and highly probability of user interesting and learning quickly.

3.3.5 Design Techniques

Design techniques are the methods is used to model the solution domain. There are many design practices for design techniques. Some of them are modern structured design, Prototyping, Rapid Application Development and Object Oriented design techniques. As this application is based on android, Object Oriented design technique is used as the design technique to develop the application. So it is easy to use in the implementation phase. [5]

In the Object Oriented design mainly includes abstract, inheritance, polymorphism and encapsulation. Universal Modeling Language (UML) plays an important role in OO design. UML allows us to build easy to use and easy to understand models of objects so that programmers can easily write software. [6] Where,
- Use-Case diagrams with narratives – shows what the system needs to do. [7]
- Sequence diagrams – shows how the objects interact overtime. [8]
- Activity diagrams – shows object states at a specific timeline. [9]
- Class diagrams – shows the needed objects and relationships between them.

User friendly interfaces can be easily implemented with android. It increases the quality of the application and client get confident with the system. Learning rate is also increased if it has been implemented using user friendly interfaces.

Following diagram Figure 3.2 illustrates overall Use Case of the Mobile Campus Navigation system. Sequence diagrams for the modules are attached in Appendix C for future reference.

![Use Case Diagram of the system](image-url)
The system of Mobile Campus Navigation with Augmented Reality is to assist the user to identify the buildings/departments inside the campus and mainly focuses on finding location and details of officials easily. Mainly five modules has been used to implement the application in order to make the development and comprehension easier. The modules are as follows,

1. Outdoor navigation module
2. Indoor navigation module
3. Official availability module
4. Official’s login module
5. Administration module

Above modules are explained with details and some of them are explained along with Use Case diagrams. Please refer Appendix C for the rest of the Use Cases and narratives.

Deployment diagram for the system is depicted below in Figure 3.3

![Deployment Diagram](image_url)

*Figure 3.10: Deployment diagram of the system*
3.3.5.1 Outdoor Navigation Module

This module is designed to navigate outdoor locations. Retrieve the POIs and the direction of the phone then display the related buildings as labels in augmented reality view. In the map view, the longitude and latitude of the user’s current position are taken and display the path between current position of user and the destination that is what user wanted to go.

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Outdoor Navigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actors</td>
<td>Navigator</td>
</tr>
</tbody>
</table>

**Overview**

Details of the departments in augmented, map, list view are displayed.

**Preconditions**

POIs should be included in the database.

**Flow of event**

1. Retrieve the user current position.
2. Get the direction of the user or the phone.
3. Fetch the query and retrieve data from database.
4. Display the details of the buildings as labels according to the user direction.

Table 3.1: Use case description for outdoor navigation module

![Use case diagram for the module](image)
3.3.5.2 Indoor navigation module

2D map of the building is shown to the user. Every places inside the building is drown on the map and paths and directions are included and clearly displayed. If the specific building contains one or more flats, 2D maps for each floors are included. When the user arriving to the building in AR mode and when the user select the building, then it shows the 2D map of that building containing small description of the floors. Maps and other details are stored in the server side database. Once the user select the floor then the data is fetched from the data base.

3.3.5.3 Official availability module

This module is to give official’s details for the user. This is gives details about the lecturer or the official’s details. This is included QR codes that each officials are given separately. While creating QR code, unique id and other basic details of the specific official are given. The details of the available time slots, telephone numbers and other personal information are stored in the database as per official.

3.3.5.4 Official’s login module

Time slots for each officials are stored in the database. But they are tended to change. To change, delete or add data into the database is easy to officials along with this module. Each officials have unique username and password, so in the login module they should provide username and password. Username is required to identify the person uniquely and the password is for the security. After the official logged into the system, updating their details is very easy as user friendly interfaces are used.
3.3.5.5 Administration module

This module is to developing team or the admin. This module provides features for the administrator to update POIs, 2D maps, lists and add or remove officials from the system. Administrative privileges are given to administrator and the developing team. Administrator is a technical person who does the maintenance of the system.

All the modules are accessible to the administrator. This module is also provides to take backups and store each copy in other specific place to recover data in case of a system failure or corruption of database, and restore the data.

3.3.6 Database Design

Database design is achieved through data modeling. This is a technique used for defining business requirements for a database. Centralized architecture is used as the high efficiency and data are stored in one place is easy to maintain.

Tables were created to store data using MySQL database management system and the database is located in the database server. Figure 3.6 is illustrates the database structure of the system.

![Figure 3.12: Database Structure of the system](image)

Following Figure 3.6 shows the Entity relationship diagram of the application.
There are many kinds of architectures to develop an application in IT. Some of them are PAC architecture, RMR architecture, MVC architecture, web based and gateway and platform. However implementing straight MVC in an android application is not easy and possible even though android itself is based on the principles provided by MVC. When implementing this android application, lot of effect has taken to follow MVC principles. Following is a description of android’s similarity with MVC.

- Define user interface in various XML files by resolution, hardware, etc.
- Define resources in various XML files by locale, etc.
- Extend classes like ListActivity, TabActivity and make use of the XML file by inflates.
- Can create as many classes as wish for the business logic.
- A lot of Utilities have been already written for (reuse)- DatabaseUtils, Html.

**PAC**: A less publicized but still widely used architecture is Presentation-Abstraction-Control, or PAC. The two main differences between MVC and PAC are that in PAC
the Presentation component is "dumb" while all the intelligence resides in the Controller and PAC is layered. Again, see the pretty picture.

**MVC:** The system has adapted the MVC principles which is being followed by most of the professionals in the IT industry which has a full capability to support dynamic interactivity with the database as well. This also supports for the very special feature of OO - reusability.

MVC methodology typically splits the architecture of the system into 3 distinct parts which are kept operationally separate but interact with each other to deliver all aspects of the system and the administrate the system. The main aim of the MVC architecture is to separate the business logic and application data from the presentation data to the user.

Adhering to MVC architecture helps you to attain a perfect design for an enterprise application. The following illustration in figure 3.8 shows the simple interaction followed in the MVC framework.

![MVC Architecture](image)

*Figure 3.14: MVC Architecture*

There is a common control flow in all forms of MVC built applications. The ‘Controller’ lies at the core of the architecture and it interacts with the user through the application interface. Behind the scene, it communicates with the Model and the View components of the architecture.

The ‘Model’ actually envelops the database so that the Controller can notify and direct the database according to the user actions on the application. The database is modified in accordance with the request submitted by officials, administrator or the system itself.
On receiving query request the controller handles the model and the model notifies ‘View’ to update the system or graphically shows in the user interface. This cycle runs again and again while user uses the application.

### 3.3.8 User Interface Design

The main source of interaction between a user and the system are the user interfaces where the user is allowed to work with the system without bothering about the back-end logics which are neatly hidden from the user.

Since the application has adapted the MVC framework, the main advantage of MVC is that we separate presentation from logic, keeping everything much cleaner. Views make it easy for us to present a flexible and consistent interface, and to change it if the user requests without worrying about the internal business rules. [10]

1. Simple, graphical user interface: The user interface is designed to be simple to use with graphical elements. Texts are simple, clear and readable. Colors are used according to a theme which makes it more usable.

2. Minimal surprise: Interface is designed considering the user experience of using android application with providing minimal surprise.

Some other main user interface design rules were followed while designing the system. As specified below.

- Provide clear and consistent navigation along with easy access.
- Logical grouping of tasks where a collection of links are provided for each module.
- Display visual elements regarding their priority, by following special organization which allows for quick location and interpretation.
- Use images or icons to make the user to feel comfortable while using the system.
- Choose a font and the text-size which is clear and readable.
- Display meaningful error messages and proper instructions when the user encounters any errors.
Main Interface

This is how the user is displayed in the very first step before running the applications. It is very simple and main functions are given directly without putting the user into trouble. Figure 3.8 is shown the basic interface of the application.

![Main Interface](image)

*Figure 3.15: Main interface of the system*

Admin and Client Login Interface

Lecturers and Administrators are given this login interface to authentication purposes (in order to update the necessary information of the system). In Figure 3.8 is illustrated the Login Interface.

![Login Interface](image)

*Figure 3.16: Login interface*
Outdoor Navigating Interface (Augmented View)

This view is the main view of outdoor navigating and displays the POIs (Points of Interest) in an augmented view.

![Augmented view](image1)

*Figure 3.17: Augmented view*

Indoor Map Interface

The view of indoor map interface is depicted below.

![Indoor Map view](image2)

*Figure 3.18: Indoor Map view*
3.4 Chapter Summery

This chapter presented many important details about context analysis and design phase of the proposed system. It gave a clear and informative description about the techniques used to gather user requirements and analysis, expected functional and nonfunctional requirements from the system, use-cases, use-case descriptions and other important modeling diagrams, software process model used in this software project, importance of various design architectures, design requirements and design architectures used to implement this system, Main user interfaces of the system etc. With the knowledge gained from this chapter, next chapter will discuss about the development phase of the application.
Chapter 4- System Development

Design and Development processes transform the specification to an executable program, which are, most of the time interleaved. The system has been implemented in order to fulfil the requirements identified so far in the system analysis phase and to satisfy all the requirements of main stake holders of the system. The design patterns and technologies identified in the system designing phase were highly supported to implement the system timely and efficiently.

4.1 Development Environment

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer with</td>
<td>• Microsoft Windows 7 Professional – 64 Bit</td>
</tr>
<tr>
<td>• Intel(R) Core(TM) i7 2670QM 2.2 GHz</td>
<td>• WAMP 2.4</td>
</tr>
<tr>
<td>• 4 GB RAM</td>
<td>o PHP 5.4.16</td>
</tr>
<tr>
<td>• 750 GB Hard disk</td>
<td>o Apache 2.4.4</td>
</tr>
<tr>
<td></td>
<td>o MySQL 5.5.12</td>
</tr>
<tr>
<td></td>
<td>• Android SDK Build-Tools Revision 19.0.3</td>
</tr>
<tr>
<td></td>
<td>• Android 4.4.2 (API 19)</td>
</tr>
<tr>
<td></td>
<td>• Metaio SDK 5.5</td>
</tr>
<tr>
<td></td>
<td>• Java Platform (JDK 7)</td>
</tr>
<tr>
<td></td>
<td>• Eclipse IDE for Java Developers</td>
</tr>
<tr>
<td></td>
<td>Version: Kepler Service Release 2</td>
</tr>
</tbody>
</table>

| Smart phone with          | • Android Jelly Bean 4.3                      |
| • Quad-core 1.5 GHz Krait processor | • Java SDK and JRE                           |
| • 2 GB RAM                |                                               |
| • 32 GB Primary Storage   |                                               |
| • 5 Megapixel Camera      |                                               |
| • GPRS, EDGE, HSDPA, HSUPA Enabled |                                               |
| • Sensors :- Accelerometer (motion), Ambient light, Gyroscope, Proximity |                                               |
| • GPS                     |                                               |

*Table 4.1: Development environment*
When finalizing the implementation environment various aspects were taken into consideration. When selecting the development software, most of them were free and open source (FOSS) which will not cause much trouble when getting the copyrights of the system. The following will give a brief summary of development environment.

Further the system was implemented in responsive way such that it is fully compatible with all modern Android operating systems in mobile phones and will support for mobile devices like tablets regardless of the android version and the screen size of devices.

4.2 Technologies

- Android was chosen as the main development language used to develop the system.
- MySQL was used to handle all the database queries in the system.
- JavaScript was used to develop all the client-side validation.
- AJAX which is based on JavaScript and XML was used to get data from the server without refreshing it repetitively.
- Android and QR Code technologies were used to implement a QR code scanner application which works in an Android supported mobile device, in order to process QR code scanning of attendance checking module.

4.3 Tools

MySQL Workbench

It is a visual database design tool that integrates SQL development, administration, database design, creation and maintenance into a single integrated development environment for the MySQL database system.
Firebug 2.0 Debugging Tool

It is a web development tool which can be installed in ‘Firefox’ web browser in order to inspect HTML and modify style and layout in real-time. Further it provides JavaScript debugging, analyzing network usage/performance and many more to support web development tasks.

‘LogCat’- Android debugging tool

When developing Android applications in Eclipse the runtime exceptions messages are NOT displayed in the console window. Instead, the Android SDK comes with a tool, called LogCat, that logs all the platform messages. The LogCat view displays logs generated by the Android emulator and by the mobile application:

Robotium Recorder

Records professional Android UI test cases in minutes. Records from emulators and actual android devices. Fully supports for native and hybrid Android apps. This tool has an Eclipse IDE plugin - Easy for anyone to use.

Zxing online qrcode generator tool

for the qr code generation(which contains official details and should be displayed at campus officials office door),zxing online qrcode generator tool was utilized.quality and accurate qr code generation can be obtained from this online tool.

4.4 Open source frameworks used and why

Metaio SDK for Android

The Metaio augmented reality SDK is one of the best, and most flexible AR development platform which is famous among thousands of developers. It serves best for any kind of
augmented reality development requirement. It has its own frameworks for Android, iOS, and Windows platforms. This backend framework enabled to develop the system much faster than writing code from scratch, by providing a rich set of libraries for commonly needed augmented reality tasks such as location-based tracking, as well as a simple interface and logical structure to access these libraries. [6]

Reasons for use

- Offers the ability to recognize and track nearly any real world image, object or environment
- Offers both continuous and client-based visual search,
- Modular structure of SDK allows for writing a single experience once, and deploying it to multiple platforms (Android, iOS, PC)
- Supports HTML5 & JavaScript development
- Supports both client (offline) and cloud-based content. Store AR content on the app or pull it from the cloud - your choice
- The Metaio SDK comes with its own rendering engine, no need to buy a different one but if you do, it supports the unity mobile plugin
- Easy to learn, understand and deploy as well: it provides excellent documentation to learn augmented reality tasks with clear examples.
- Provides easy customization
- Flexible and easily manageable with Android development.
- Built in security and encryption mechanisms.
- Large and active user community: the Metaio website has a help desk and forum to support anyone who is looking for answers for problems which arises when developing the system.

Reasons for use

The Metaio SDK is modular framework that includes the capturing component, the sensor interface component, the rendering component, the tracking component and the Metaio SDK interface. The interface provides interaction between the application and the other 4 modular components. Under this setup, the details of implementations are
encapsulated and the user doesn't have to worry about the details of capturing, rendering, sensors or tracking. The major functionalities are realized through simple SDK APIs that "talk" to the other parts of the SDK, which results in the easy implementation of AR applications. The Metaio SDK is compatible with all major platforms for software development: Android, iOS, and Windows. The platform-specific interfaces of the Metaio SDK can easily interact with the development environment. The combination of the Metaio SDK and platform SDK leads to AR applications.

**High-level system overview**

![Figure 4.19: High level overview structure](image)

**Deploy view**

This view is attached below
4.5 Used Third Party Components and Services.

Zxing QR Code library

Zxing is a free and open source Multi-format 1D/2D barcode image processing library with clients for Android, Java. Official availability module was successfully implemented with the support of Zxing library. All QR Code scanning classes and procedures were extended from this library while integrating to our system. Moreover, the creation of static QR Codes were also done by using the Online tools of Zxing QR code library.
Google Maps

Google Maps JavaScript API v3 is a free service, available for any web site that is free to consumers. It lets people to embed Google Maps in web pages and provides number of utilities for manipulating maps and adding content to the map through variety of services, allow to creating robust customized maps applications. List view and Map view of MCNAWAR were developed using the directions and map APIs of Google Maps API.

4.6 Major Code Segments

Metaio SplashActivity class

```java
package com.uocnavigatehelper.arview;

import android.app.Activity;
import android.app.ProgressDialog;
import android.content.Intent;
import android.os.AsyncTask;
import android.os.Bundle;
import android.view.View;

import com.metaio.cloud.plugin.MetaioCloudPlugin;
import com.metaio.sdk.jni.IMetaioSDKAndroid;

/* Metaio sdk base class for handle AR browsing*/
public class SplashActivity extends Activity
{
   static
   {
      IMetaioSDKAndroid.loadNativeLibs();
   }

   /**
    * Progress dialog
    */
   private ProgressDialog progressDialog;

   @Override
   public void onCreate(Bundle savedInstanceState)
   {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.main);
      JunaioStarterTask junaioStarter = new JunaioStarterTask();
   }
}
```
@Override
protected void onResume()
{
    super.onResume();
}

@Override
protected void onPause()
{
    super.onPause();
}

@Override
protected void onStop()
{
    super.onStop();
    if (ProgressDialog != null)
    {
        progressDialog.dismiss();
    }
}

/**
 * Launch junaio live view
 */
private void launchLiveView()
{
    // Set  channel id in /res/values/channelid.xml
    int myChannelId = getResources().getInteger(R.integer.channelid);

    // if  set a channel ID, then load it directly
    if (myChannelId != -1)
    {
        startChannel(myChannelId, true);
    }
}

public void startAREL(View v)
{
    startChannel(174470, false);// start AREL test
}

public void startLb(View v)
{
    startChannel(281840, false);// start our UOC Navigate Helper channel
}

public void startChannel(int channelId, boolean andFinishActivity)
{
    // To use the old MetaioCloudARViewActivity use this
    // Intent intent = new Intent(SplashActivity.this,
    // MetaioCloudARViewTestActivity.class);
    // instead of this
}
Intent intent = new Intent(SplashActivity.this, MainActivity.class);
    intent.putExtra(getPackageName() + ".CHANNELID", channelId);
    startActivity(intent);
    if (andFinishActivity)
    finish();
}

public void startQR(View v) {
    try{
    Intent intent = new Intent(Intent.ACTION_MAIN);
intent.setClassName("com.uocnavigatehelper","com.uocnavigatehelper.QRScan.QRActivity");
    startActivity(intent);
}catch (Exception e) {
    e.printStackTrace();
}
}

public void startLm(View v) {
    try{
    Intent intent = new Intent(Intent.ACTION_MAIN);
intent.setClassName("com.uocnavigatehelper","com.uocnavigatehelper.ARview.listmapactivity");
    startActivity(intent);
}catch (Exception e) {
    e.printStackTrace();
}

private class JunaioStarterTask extends AsyncTask<Integer, Integer, Integer> {

    @Override
    protected void onPreExecute() {
        progressDialog = ProgressDialog.show(SplashActivity.this, "junaio", "Starting up...");
    }

    @Override
    protected Integer doInBackground(Integer... params) {
        // TODO Set authentication if a private channel is used
    }
}
QR Code Scann main class.

```java
package com.uocnavigatehelper.QRScan;

import java.text.DateFormat;
import java.text.SimpleDateFormat;
import java.util.Calendar;
import java.util.Date;
import java.util.Locale;

import android.os.Bundle;
import android.app.Activity;
import android.content.Intent;
import android.text.util.Linkify;
import android.util.Log;
import android.view.Menu;
import android.view.View;
import android.widget.Button;
import android.widget.ImageView;
```

// MetaioCloudPlugin.setAuthentication("username", "password");

// Start junaio, this will initialize everything the plugin needs
int result = MetaioCloudPlugin.startJunaio(this, getApplicationContext());

    return result;

}

@Override
protected void onProgressUpdate(Integer... progress) {
}

@Override
protected void onPostExecute(Integer result) {
    if (progressDialog != null) {
        progressDialog.cancel();
        progressDialog = null;
    }

    if (result == MetaioCloudPlugin.SUCCESS)
        launchLiveView();
    else
        Utils.showErrorResponse(result, SplashActivity.this);
}

```
import android.widget.LinearLayout;
import android.widget.RelativeLayout;
import android.widget.TextView;

public class QRActivity extends Activity {
    private Button scan;
    private TextView txt1, txt2, txt3, txt4, txt5;
    private TextView status, role;
    private ImageView image;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
        scan = (Button) findViewById(R.id.btnScan);
        txt1 = (TextView) findViewById(R.id.scan_txt1);
        txt2 = (TextView) findViewById(R.id.scan_txt2);
        txt3 = (TextView) findViewById(R.id.scan_txt3);
        txt4 = (TextView) findViewById(R.id.scan_txt4);
        status = (TextView) findViewById(R.id.textView2);
        role = (TextView) findViewById(R.id.textView3);
        image = (ImageView) findViewById(R.id.imageView1);

        scan.setOnClickListener(new View.OnClickListener() {
            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                Intent intent = new Intent("com.google.zxing.client.android.SCAN");
                intent.putExtra("SCAN_MODE", "QR_CODE_MODE");
                startActivityForResult(intent, 0);
            }
        });
    }

    public void onActivityResult(int requestCode, int resultCode, Intent intent) {
        String Type = null, Name = null, Org = null, Tel = null, Email = null, Adr = null, Url = null, Note = null;
        String weekDay;
        if (requestCode == 0) {
            if (resultCode == RESULT_OK) {
                String contents = intent.getStringExtra("SCAN_RESULT");
                String format = intent.getStringExtra("SCAN_RESULT_FORMAT");
                // contentTxt.setText("CONTENT: "+ contents);
                // Linkify.addLinks(contentTxt, Linkify.ALL);
            }
        }
    }
}
/* handles the qr scan*/
public void onActivityResult(int requestCode, int resultCode, Intent intent) {
    String Type = null, Name = null, Org = null, Tel = null, Email = null, Adr = null, Url = null, Note = null;
    String weekDay;
    if (requestCode == 0) {
        if (resultCode == RESULT_OK) {
            String contents = intent.getStringExtra("SCAN_RESULT");
            String format = intent.getStringExtra("SCAN_RESULT_FORMAT");
            // contentTxt.setText("CONTENT: "+ contents);
            // Linkify.addLinks(contentTxt, Linkify.ALL);
        }
    }
if(contents.startsWith("BEGIN:")){
    String[] tokens = contents.split("\n");
    for (int i = 0; i < tokens.length; i++){
        System.out.println(" "+tokens[i]);
        if(tokens[i].startsWith("BEGIN:"))
        {
            Type= tokens[i].substring(6);
        }
        else if(tokens[i].startsWith("N:"))
        {
            Name= tokens[i].substring(2);
        }
        else if(tokens[i].startsWith("ORG:"))
        {
            Org= tokens[i].substring(4);
        }
        else if(tokens[i].startsWith("TEL:"))
        {
            Tel= tokens[i].substring(4);
        }
        else if(tokens[i].startsWith("URL:"))
        {
            Url= tokens[i].substring(4);
        }
        else if(tokens[i].startsWith("EMAIL:"))
        {
            Email= tokens[i].substring(6);
        }
        else if(tokens[i].startsWith("ADR:"))
        {
            Adr= tokens[i].substring(4);
        }
        else if(tokens[i].startsWith("NOTE:"))
        {
            Note= tokens[i].substring(5);
        }
        txt1.setText("NAME:"+Name);
        txt2.setText("DEPARTMENT:"+Org);
        txt3.setText("TEL:"+Tel);
        txt4.setText("EMAIL:"+Email);
    }

    Linkify.addLinks(txt3, Linkify.ALL);
    Linkify.addLinks(txt4, Linkify.ALL);
}
}

SimpleDateFormat dayFormat = new
SimpleDateFormat("EEEE", Locale.UK);
Calendar calendar = Calendar.getInstance();
weekDay = dayFormat.format(calendar.getTime());
4.7 Chapter Summery

This chapter discussed about the implementation phase of the software project. It described about the usage of major tools and technologies, software sdks, software frameworks, Third Party Components and Services etc. used to implement this project successfully. Major code segments of important classes were also depicted and the importance of major methods were expressed using comments. Detail understanding about the implementation technologies of this system, can be retrieved after study this chapter.
Chapter 5- Testing and Evaluation

5.1 Introduction

Software testing is a critical element of software quality assurance that represents the ultimate review of specification, design, and code generation. The testing is comprised of Verification and Validation methods.

Verification – refers to the techniques of finding out whether the built software meets all the customer requirements

Validation - refers to the techniques that ensure the software meets all the specified functional requirements.

The testing process is considered dynamic; given that the process is carried out on an executable function of the system. Testing is a vital process to ensure a perfectly working system with fewer errors is delivered to the customer.

5.2 Testing Procedure

Software testing and implementation are interleaved most of the time seeing that both phases work with executable system components. The Iterative RUP development life cycle made it possible to test Iterative increments of the software.

Structural testing techniques were followed in this phase including “white box” testing tests how a program/system does something. Functional testing techniques were used, which includes “black box” testing tests the behavior of a system or program. These techniques were exploited in different testing levels like unit testing- test components in isolation, integration testing, regression testing-make sure unchanged functionality remains unchanged, interface testing, defect testing, system testing and acceptance testing.
Since this is a system which followed Object oriented methodology, Object oriented testing was also carried out in this phase. Here individual operations associated with objects were tested initially, followed by testing individual classes and clusters of objects, and finally testing the system as whole.

5.3 Test Plan and Test Cases

Test plan, which covers all types and phases of testing, was used as a guide for the entire testing process. The test plan was designed before the implementation of the system. A test plan includes: test objectives, schedule and logistics, test strategies, and especially test cases. Test cases were created once the test plan was designed. That consists of data, procedure, and expected result, and represents just one situation under which the system or part of the system might run. Test cases were designed for each module separately to reduce complexity of the testing process. The following tables specify some test cases.

5.3.1 Administrative Module

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Step to test</th>
<th>Expected Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Create new official’s account</td>
<td>Fill in parameters for the user who already doesn’t have an account</td>
<td>The administrator should be able to create a new use</td>
</tr>
<tr>
<td>02</td>
<td>Change the user account settings</td>
<td>Edit Account type in the account interface</td>
<td>The administrator must be able to change privileges</td>
</tr>
<tr>
<td>03</td>
<td>Take backups</td>
<td>Enter username, password and click backup</td>
<td>Backups are taken and a copy is sent to chosen location, if not successful, display error</td>
</tr>
</tbody>
</table>
select location to save backup files

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Step to test</th>
<th>Expected Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>Request to view account users</td>
<td>Click view all</td>
<td>Display the users and their related details</td>
</tr>
</tbody>
</table>

Table 5.1: Test cases for administrative module

5.3.2 Officials’ Login Module

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Step to test</th>
<th>Expected Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Login with uname &amp; password</td>
<td>Fill the parameters and click login</td>
<td>If valid, user should be able to log in else display error message</td>
</tr>
<tr>
<td>02</td>
<td>Update time slots and schedule</td>
<td>Fill the parameters and click submit</td>
<td>Confirmation message should be displayed then it is confirmed update and show success message</td>
</tr>
<tr>
<td>03</td>
<td>Check time</td>
<td>Click show time</td>
<td>Display all the time slots and venue he/she has updated</td>
</tr>
<tr>
<td>04</td>
<td>Change privilege</td>
<td>Select the variable which is needed to hide and then click “only me” button</td>
<td>Hiding data can be only seen by that particular user</td>
</tr>
<tr>
<td>05</td>
<td>Change username/password</td>
<td>Click change username or password and fill the current password and new password twice</td>
<td>If the current password matched show success message, else give another 2 attempts then block the account</td>
</tr>
</tbody>
</table>

Table 5.0.2: Test cases for officials login module
5.3.3 Outdoor and Indoor Navigation Module

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Step to test</th>
<th>Expected Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>AR Browsing</td>
<td>Open application and click AR view button</td>
<td>User automatically go to AR mode and start to display labels respectively to POIs</td>
</tr>
<tr>
<td>02</td>
<td>Evaluate distance</td>
<td>Switch to AR view</td>
<td>Shows the length to the locations from the user, if the user move length must change</td>
</tr>
<tr>
<td>03</td>
<td>Operate application</td>
<td>Open the application</td>
<td>If the user doesn’t connect to internet, pop up message should be displayed.</td>
</tr>
<tr>
<td></td>
<td>without connecting to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Read description of</td>
<td>Click on the label that is shown above the building in AR view</td>
<td>Small description should be displayed</td>
</tr>
<tr>
<td></td>
<td>the building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Find indoor location</td>
<td>Click on the label that is shown above the building in AR view, click on the floor 1,2,3,…..etc.</td>
<td>2D map for each floor of the specific building should be displayed</td>
</tr>
</tbody>
</table>

Table 5.3: Test cases for navigation module

5.3.4 Officials’ Availability Checking Module

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Step to test</th>
<th>Expected Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Scan the QR code</td>
<td>Click the scan button and keep the phone close to the QR code</td>
<td>Displaying official’s details of scanned QR code</td>
</tr>
</tbody>
</table>
5.4 Test Data and Test Results

The data needed to test the functions of the system, were created by referring to the past data gathered from the document sampling technique followed in the analysis phase. Model data sets were generated for each module in order to test the functionalities.

Each data field in individual form was tested with sample dummy data to ensure the working condition of each form element. A common set of error messages were reused in suitable places to reduce burden and confusion by giving different error messages for same functionalities.

Since our application is based on the MVC architecture mainly assists us in code reuse, same error messages were re-used in appropriate places. According to the test plan provided in Chapter 5 - Implementation the test cases were applied and was used to get appropriate responses and errors. The detected errors were corrected right away to provide a consistent, working system as whole. The following test cases and resulting screenshots are given below to enlighten the user about the process carried out in the testing phase.

**Administrative Module**

<table>
<thead>
<tr>
<th>Test No</th>
<th>Testing Steps</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Fill in the user type, employee ID, initial password and status in account form and click on the create button to create the account.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td><strong>User Successfully Created</strong></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Try to create an account for an existing user</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td><strong>User already exists</strong></td>
<td>✓</td>
</tr>
</tbody>
</table>

*Table 5.4: Test cases for official availability checking module*
<table>
<thead>
<tr>
<th>Test No</th>
<th>Testing Steps</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Looking for outdoor locations in AR view and viewing possible labels</td>
<td>✔</td>
</tr>
</tbody>
</table>

**AR Module with Indoor and Outdoor Navigating**

Table 5.5: Test results for administrative module
02 Select the AR mode from others after open the application

03 Select the list view
### Checking Officials’ Availability Module

<table>
<thead>
<tr>
<th>Test No</th>
<th>Testing Steps</th>
<th>status</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Set the phone on the QR code and Click Scan button</td>
<td><img src="image" alt="Localisation success" /></td>
</tr>
</tbody>
</table>

Displaying the details of the official

---

**Table 5.6: Test results for navigation module**

- **Checking Officials’ Availability Module**
  - **Test No 01**: Set the phone on the QR code and Click Scan button.
  - **Status**: Localisation success.

---

Finding inside location using 2D map

04
Users’ feedback

The Overall Feedback ratings of each officials and students were taken and converted into a graphical evaluation chart.
The final feedback received from the survey was significantly positive and pleasing. Some suggestions were taken into consideration at the implementation as well. Hopefully other suggestions will be implemented with the future enhancements.

5.5 Acceptance Testing

The system is given to some university students including male, female and new comers. They are given the system to use and send the feedbacks. Majority expressed that it is very easy to handle and not necessary to operate more knowledge. As this application is based on the mobile phone, the younger generations are very interested to use it.

Some small issues are raised and some ideas are given while using the application. They can be solved easily as this application based on OO concepts and RUP methodology. Some of the problems have already been solved.

The final result of the test indicated that the system is easy to handle and work with, user friendly with pleasant working environment. In addition, it can be used to perform transactions in an efficient way. We also came across some bugs which were fixed right away. Some feedbacks and suggestions given by the client were implemented to give better performance and acceptance. Finally, the overall achievement of this project was satisfying and considered that all the objectives of the project have been met.

5.6 Chapter Summary

This chapter discussed about another aspect of software project development; software testing and evaluation. It is very important to hold various kinds of testing procedures before the system is presented to the client. Test cases have been built to check the accuracy and defects of every single functionality. With analyzing test results, the developer can identify weaknesses of the functionalities of the system and take suitable actions like redesigning, to correct those defects.
Chapter 6- Conclusion and Future Work

6.1 Conclusion

Mobile Campus Navigation Application with Augmented Reality is an application with severely unique functions and properties that delivered in a well user friendly way to typical users of the system. It apparently gives the user productivity with the combination of technical and user requirements in advance. This system is being introduce to enhance the user satisfaction and ease the self-touring experience within the University of Colombo.

The most typical needs of students and visitors of the university is been calculated and taken into consideration for the development of the system. There are no heavy user involvement in data or information processing only they need to get to know the correct details for the purpose of navigating through the premises of the university. Before this system was first introduced and implemented, many of the visitors had faced the common general issues that have being addressed by the application in present time.

The implementation of the MCNAAR has quite impact on the university environment, given that the system allows students, lecturers and visitors navigate in both outdoor and indoor, search for a place of interest, view availability of a person of interest with complete ease. According to feedbacks from users, the non-cumbersome of self-touring has motivated them on using and spreading this systems usefulness to others. It’s more of time and effort saving of the users of the system which is an advantage that differentiate it among other systems.

6.2 Future Work

With the limitations and difficulties faced and innovation of newly occurred ideas while implementing this software solution, several future improvements were identified in order to have a better software system in the future. Using Wi-Fi technology is one of better and possible alternative for both outdoor and indoor location tracking. The system
can then be able to locate user’s indoor position with an accuracy of up to 4-9 meters using UCSC’s well-developed Wi-Fi network. Then the system will be able to provide indoor locations of users with the same accuracy as of outdoor locations. For outdoor location tracking we can still use GPS technology with a good accuracy. The system currently using 2D maps to view indoor floors of a building. Converting those maps to 3D, is another better approach to be taken for guide users.

For Students

- Connect with classmates and faculty through social media integration
- Use enhanced search directory to find buildings, classrooms, professors, and more
- Receive school news and updates
- Create personalized favorites list

For Faculty

- Learn valuable information about students and visitors through analytics
- In-app advertising and sponsorship revenue opportunities
- Stay connected with students and alumni before and after they graduate.

For Visitors

- City and campus search directory
- News and announcements/Calendar of events

For Assistive

- Disability-focused interactive campus map
- Voice and touch in-app options
- Ability to locate buildings, professors, and more with campus Directory

6.3 chapter summary

This chapter gave a brief description about the conclusion of the ‘Mobile Campus Navigation Application with Augmented Reality’ software project and the future improvements that are expected to have in another upcoming version of this system, with full permission and acceptance of the Clint. Various improvements have been already identified and some are currently in progress to help ‘MACNARR’ stand up like a real giant in near future in the context of mobile campus navigation applications.
List of References


[Online; accessed 17-March-2014].

Appendix A - User Manual

When a particular user is in need of visiting the University of Colombo for a specific interest, he/she fore mostly must find the route to take from user’s current location to the place where he/she wants to visit within the university. Using this application in user’s mobile device, when the user first launch the application he or she is given three basic module functions mentioned accordingly below,

- Location Based Route Information Module
- Location Tracking Module
  - Outdoor location navigating
  - Indoor location navigating
- Lecturer Availability Checking Module

User access to the University Premises

To access the university user must find the correct path to take. By starting the application he will be granted to view the choices on the interface which pops up as soon as the application starts up.

![UOC Navigate Helper](image)

Figs: A.1

It’s not so fancy but plain interface with a list of those above mentioned modules in separate choices. There, user should choose List View/Map View function, where the user is then given a list of choices which are locations of main interests within the University of Colombo.
There the user can scroll up and down and tap on the exact point of interest where he/she wants to visit. Result is then depicted as a top down 2D map which is integrated by using Google Map API functions.

After completing this steps the user is now in a position where he/she could travel from where ever is currently at, to the University of Colombo. Of Course user must be in online in order to work in this module properly.
User guidance navigation with Augmented Reality Browser

Thereafter all the navigation functions are done through the second module Location Tracking Module. To use this function user must go to the first main interface again and choose the function of Navigate UOC Outdoor Locations. It automatically activates camera of user’s mobile device, all the user is have to do is then just point his/hers device around him locating different buildings or areas. The particular unique thing the user will experience is that with the help of Augmented Reality technology he will see locations of interest’s right at the direction where his/hers mobile device is pointing at. All the buildings and areas are depicted as their GEO Coordinates and pinned down with the displacement difference between of the users GEO coordinates and the location that pops on the mobile device screen.

*Figure A.4*
User is then just have to follow the pointing direction of the point of interest where shown on the mobile device. The user can choose either landscape view or portrait view.

Figure A.5: Landscape view

Figure A.6: Portrait view
There is an additional function that gives the particular user with more details, he/she only wants to tap on one of the popping up location box and then it will automatically interpret the details of that specific point of interest where it would be much more additionally helpful to the user of the system.

User guidance indoor navigation

Indoor location navigation is another useful functionality which is provided by this system. This function helps users to locate indoor locations where GPS signals tend to become very weak. Users can tap on any outdoor location (where GPS signals are sufficiently accurate) which results a popup box displaying the indoor floors of that particular outdoor location. Users have to scan a LLA marker, which is displayed in front of every building and their location is updated in a red dot in indoor floor map as shown in below.
Lecturer Availability Checking Module

Visitors and Students are in need of meeting lecturers in a university faculty, so they need to be noticed the availability of the person whom they want meet. This need has being considered in our requirements and in the system there is a module which meets that particular need of finding the person of interest. The user will find if the lecturer is not in his/hers room at the time the user visits, they can just point out there mobile device and launch our application, tap on get officials details, and then in the window which comes tap the scan button and point the device in order to read the QR Code which resides on the door of the lecturer.
Then the application will automatically scan the QR Code and gives the user updated information of the lecturer availability, his/ hers current location, what times would he/she be available, and furthermore the application provides the user with the details to make contact with lecturer. There the user would get lecturer phone and email contact details and just choosing which medium of contacting the lecturer the application will automatically guide and help the user to do so.
Appendix B - System Manual

This documentation is to assist the software engineers, administrators who wish to continue further with this project work, to install and configure the system in technical perspective. The system documentation can be referred if there are any changes to be made in the MCNAAR.

In order to install the system, the Device chosen for installation should meet the following prerequisites of Hardware and Software.

**Hardware Requirements**

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Recommended Requirements</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>1.8GHz Intel core 2 Duo or similar or newer processor.</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>512MB RAM or more</td>
<td></td>
</tr>
<tr>
<td>Hard disk capacity</td>
<td>Minimum 1GB free disk space or Higher.</td>
<td></td>
</tr>
<tr>
<td>Display</td>
<td>1024x768 or resolutions above High .Colour 16-bit display.</td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>Minimum 512kbps ADSL connection.</td>
<td></td>
</tr>
<tr>
<td>An android device</td>
<td>1GB RAM or more with 256MB free disk space,GPS enabled, Compass/ Magnetometer, Proximity sensor, and Accelerometer enabled.</td>
<td></td>
</tr>
</tbody>
</table>

**Software Requirements**

<table>
<thead>
<tr>
<th>Software</th>
<th>Recommended Requirements</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System for Computer</td>
<td>Windows XP (32-bit), Vista (32- or 64-bit), or Windows 7 (32- or 64-bit)</td>
<td></td>
</tr>
<tr>
<td>Bundle Package</td>
<td>Newest Android SDK Tools, Android Platform-tools, Eclipse + ADT plugin, MySQL5.6, JDK 6,</td>
<td></td>
</tr>
<tr>
<td>Code Editor</td>
<td>Eclipse IDE or suitable editor.</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Web Browser</td>
<td>Google Chrome/ Fire Fox/ Internet Explorer/ Opera/ Safari</td>
<td></td>
</tr>
<tr>
<td>Operating System for Android Device</td>
<td>Android Jellybean 4.3 or higher</td>
<td></td>
</tr>
</tbody>
</table>

**Database Access**

1. Go to 000webhost member area login by giving relevant username and password. Click ‘go to cpanel’ icon. Click on ‘phpMyAdmin’ icon. select ‘a1591567_LecDb’ database and click on ‘Enter phpMyAdmin’

2. Login by giving the username and password.
Access to Edit POIS

1. Go to 000webhost member area login by giving relevant username and password. Click ‘go to cpanel’ icon. Click on ‘filemanager’ icon, go to ‘channels’ folder inside public html folder. Inside that, select ‘arel.xml’ file and click to open or edit.
Import Android Project into Eclipse workspace

This section explains how to import the source codes into Eclipse IDE as for the development purpose.

3. Select ‘Existing Project into Workspace’ option from the Import wizard in Eclipse.
5. Tick the ‘Copy projects into workspace’ and finish importing the project.
6. Project file structure will be displayed in the ‘Package Explorer’ as mentioned in the section 4.

Run the application in android device

Install the .apk file which is generated through eclipse, of ‘UocNavigateHelper’ project on the android device, by accepting to install.
Appendix C

Sequence diagrams for the system

Official’s update
Sequence diagram for Backup

Admin

Front

Login(), (uname, password) → send (uname, password)

Database

Validate

Home page

Validate

Updated

Send request

Logout() → Send parameters

Success

Updated

Logged out

Show Login page