An Android Generic Geo-Fencing Application: Proximity Triggered Notification Service Delivery

By

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CERTIFICATION OF APPROVAL

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Approved by,

_____

(Dr. Low Tang Jung)

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January 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

_____

Luís Pedro

Abstract

The widespread availability of smartphones, presents unprecedented opportunity to devise creative software solutions that leverage on the powerful hardware embedded in this devices to aid and improve interactions between the user and the environment.

This report follows through those presets and proposes the design of an android based application that makes use of Geo-fencing. Geo-fencing is software program feature that enables the use of GPS and RFID capability to define a virtual perimeter around a "hotspot" and trigger event notifications (as 'people-devices' move into or out of the established perimeter). Immediate examples of the application of geo-fencing range from its use in supporting mobile based market campaigns, under a scenario where customers would receive offers granted their proximity of a place of interest; providing regional informational services which can support health and safety campaigns for users on a certain regional context; to more particular uses such as home monitoring activities etc.

An extensive literature Review is featured on the report to provide a support basis for the direction and comparative analysis of the factors considered in past works undertaken on the field of geo-fencing. As a result discussion on multiple implementation modules is thereby presented. The individuality of this project is its aim to provide users with a generic and intuitive software application capable of enabling the use of geo-fences to tailor to their diverse discretionary uses. Accordingly, the concept, the development effort and the working methodology employed on the course of the project are discussed. The Main remark of this report is the architectural and conceptual models proposed for the application.

Acknowledgements

First and foremost I would like to thank God for the many blessings bestowed upon my life; to my family, particularly my mother *Alexandrina Luís Pedro Saranga* for the lifetime lessons and guidance that are the very backbone of the perseverance that allowed me to pursue and cherish the opportunity to learn and thereby reinvent myself. For her efforts she graced me with the honor of recording this acknowledgement.

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Last but in no form least, to the close colleagues and peers that have at turns provided me with their instrumental and emotional support, on this note a remark to Walter Taju for his sensibility in supplying a device for prototyping.

Table of Contents

Acronyms and Abbreviations

GPS global positioning system

LBS, location based services

RFID, radio frequency identification

LDD, Location Dependent Data

TTFF, Time-to-First Fix

Cell-Id, Cellular Identification

OMA, Open Mobile Alliance

SUPL, Secure User Plane

API, Application Programming Interface

I/O, Input Output

GCM, Google Cloud Messaging

APN, Apple Push Notification

APP id, Application identification

REG ID, Registration identification

OS, Operating System

SDK, Software Development Kit

DOD, US Department of Defense

STD, Standard

UUID, Unique universal identifier

C2DM, Cloud to Device Messaging

GPRS, General Packet Radio Service

Chapter 1

Introduction

The technological revolution in the communication industry has allowed for ordinary smart mobile phones to be equipped with advanced global positioning and radio frequency identification hardware. This advance sets a whole new precedence for the application opportunities that can be derived using location based services.

The present document looks into some of those opportunities, by exploring the use of Geo-fencing into smart phone applications, to deliver a solution for proximity aware notification service delivery.

This document is submitted as the dissertation for the Final Year Project II course, requirement for eligibility to the Bachelor of Technology in Information and Communication Technology. This project took a research and Design oriented progression therefore it takes a crude overlook into the development of the project.

Background

The technological revolution in the communication industry has allowed for ordinary smart mobile phones to be equipped with advanced global positioning and radio frequency identification hardware.

This advance sets a whole new precedence for the application opportunities that can be derived using location based services to solve a wide range of problems from devising market campaigns, freight management, patient movement alert, aiding senior citizens, tracking children movements , law enforcement, asset management, etc.

While as mentioned this devices are equipped with the most advanced positioning hardware there is still the issue of having capable user tuned software to make use of this features. The native mobile phone software only covers the most basic usability features and it is up to third party developers to make use of the SDKs of the different mobile OS to produce quality software capable of extending the capability of this devices.

Problem Statement

The lack of intuitive applications that leverage on positioning technologies and geo-fence features to provide a simplified solution for location aware service delivery.

Objectives

- Investigate information on applications and particulars of Geo-fencing.
- Explore the different available geo-fencing setups and implementations.
- Propose a Geo-fence generic software application concept.
- Develop an application capable of solving the problem set forth.
- Provide users with context aware services based on geo-fences.

Relevancy of Project

Ever since the Bernays campaigns in1920's creative delivery mechanisms have been the driving force for the revolutionary path advertising has taken. The competitive scenario today has driven business owners and advertisers equal, to continuously research and improve manners to reach customers and improve customer targeting. The use of customer targeting technologies and techniques, raise two (2) main issues that are yet to be addressed, the first customer privacy and then the issue of matching customers relative interests.

Scope of Project

Globalization has had a profound impact on the way businesses address customers and the array of services they provide. The increased competitiveness and thus availability of options has led customers to judge business not only by the quality of their products but also by the convenience with which services reach them.

In modern advertising, the popularity and appeal of social networking tools has caught the interest and eye of advertisers given the potential to reach a large customer base, nevertheless the matter of advertising sound equipment to a deaf user is still an item. A more targeted delivery is obtained by harvesting customers' cookie data, but this is often associated with invasion of customer's privacy. These developments expose the need for a non-evasive ad targeting mechanisms that tailors to customer's interest.

Chapter 2

Literature Review

Context aware Services are a currently trending topic in information systems. In theory the concept tied to them is that services to users are improved and have a higher rate of delivering effective results if the parameters surrounding the service request are known. Thus the sum of all the parameters that are taken into consideration for delivering the user with relevant content are called context; of these parameters the one that captures the most relevance is location.

The first generation of location based services (2000-2007) did not feature GPS readily available as a built-in technology for mobiles, so instead location was derived using the cellular network infrastructure (network operators' centric approach). The up and coming generation of location services is supported by mobile devices that almost effortlessly determines the whereabouts of the user, has contributed significantly to improve the developments in this area [1]. However, it is important to mention that these technologies (GPS) also bear significant drawbacks, such as the inefficacy when indoors, latency of first positioning (Time-to-First Fix, TTFF) and the power consumption constraint. Küpper, Bareth, & Freese, 2011 also report that in order to overcome this shortcomings device manufacturers employ hybrid positioning technologies made of a combination of GPS, Wi-Fi and Cell-Id.

The limitations imposed by the GPS, hence require that we strongly consider the margin for error (±10 to 30 m) in the technology and shape the application design to have a series of supporting mechanisms to ensure that if an object's location is unexpectedly unavailable the object's position can be estimated [2]. In this context having reviewed a series of localization techniques with proved applications in VANets, which places extreme priority in precision even when estimating location of an object travelling relatively fast, therefore it is believed that the experience derived could be mirrored to fit the challenges experienced in other general settings [2].

With this assumption, the contemplation of Map Matching, Dead reckoning and Ad-Hoc Localization as potential techniques that could validate the concept are at the center of strategies to overcome the limitations that could arise from GPS inefficiency in challenging urban surroundings. These techniques are pointed as the main approaches given the rather conducive factors for their implementation in an urban setting; it is certainly a standard practice for Ad-Hoc to be at the fore front given the high probability of nearby hotspots that could serve as differential base to better pinpoint location. However because the prior is only valid in a setting where networks are widely deployed, for brief periods of GPS unavailability dead reckoning and map matching combination is a strong alternative because it combines the map knowledge and the last known fix to estimate the geographical domain of the user's location.

The advances in positioning technology development have not allowed only for the precision in establishing geographical domains but also for establishing the granularity of the user location within that domain, defining a representation standard capable of serving the complete granularity spectrum [3]. This capability spectrum of positioning technologies results in classification of location based services according to the precision and intensiveness of object's positioning. This classification separates applications that fall under the feature of active service mechanism which covers services such as navigation, location tracking, etc. and passive service mechanism which covers services such as checking whether an object has left a certain geographical domain after a certain period of time [4].

Geo-fencing hence falls under the classification of passive service mechanism location based services; and its main application is centered in determining the drifting status of an object within a user-specified geographical domain meaning events are triggered simply by detecting whether the object has entered or exited a virtual fence. When the desired/undesired event is met a notification is issued to the user to alert them that the event has occurred. A geo-fence can be established using a two main methods, the first using a predefined set of boundaries (longitude\latitude points) or dynamically by establishing a radius around a key location [4].

Geo-fence implementations can be mobile centric or device centric, the mobile centric version uses the Open Mobile Alliance (OMA), and in this implementation

the mobile collects data from the base stations and towers around his location and sends them to a Secure User Plane (SUPL) server, the SUPL server knows the location of every base station and thus translates the base station ID sent by the mobile into an estimate location and returns it to the mobile. As for the device centric implementation, which is based on GPS, it still makes use of the OMA standards in order to decrease the GPS time to first fix. Following the previous process once the SUPL translates the base ID and has a location estimate it also adds assistance data for constellation of GPS satellites, that way the process is accelerated and the mobile positioning is captured and measured for efficiently [1]. Still on the device centric implementation another approach that doesn't require neither the use of the SUPL server nor of the GPS, would be the use of Wi-Fi, that way it would allow for the use of geo-fencing on a more domestic setting. The process in this implementation would not require using location positioning services, all that would have to be accomplished would be that if the device leaves the home Wi-Fi connection, an alert is triggered.

The possibility of geo-fence implementations keeps expanding and as new applications and services are added to the location based standards the more flexible the services tend to become. The implementations discussed above are centered in the mobile alliance and hardly allow for third party services to make full use of the features of geo-fencing. A recent implementation has surfaced, coupling geo-fence with Google Earth and since Google is fueled by a large community base development, Android location services were established and a geo-fencing API (Google I/O 2013) established.

A further boost into geo-fencing services can be gained from coupling the geo-fence application/program with Google Cloud Messaging (GCM) to enable data to be sent from the servers to applications on android mobile phones; or alternatively a similar service could be used for iPhone users Apple Push Notification (APN). The greatest feature of GCM is that it allows third party application servers to send messages to their applications using the Application ID (App id) and the Registration ID (Reg ID), and that the application doesn't need to be running to get the message, the system wakes up automatically on delivery [5].

The review of work carried out in the area provided clearance both in terms of approaches and implementations that are customary in the industry but also contributed to bring new insights into how to improve certain aspects of the geo-fencing service. The result intended for the research being carried out is for a generic implementation capable of readily allow users to define their own parameters and make use of the geo-fencing feature according to their settings and goals. Although this goal in unlike any set forth by the authors in the works reviewed, it clear does not oppose any geo-fencing service constraints which presuppose the validity of the concept and module intended.

Chapter 3

Methodology

In the process of carrying out the work, it was important to have in place a capable planning framework to serve as a support basis to exercise guidance over the terms and conditions for the work to be undertaken. The structure was devised so that the project progression could easily be addressed and monitored. The discipline applied in adhering to this outline is the root for the consistency achieved along the project. The project objectives and scope are the defining marks applied to selecting and tailoring a methodology that would be efficient for the project.

The top priorities to be addressed by the methodology were defined upfront; cementing therefore the metrics against which the outcomes would be benchmarked:

- Ability to deliver meaningful estimates of the project progress.
- Effortlessly maintain the supervisor appraised of the direction and stage of the project.
- Display a clear understanding of the scope of work to be realized and tasks involved.
- Identify pitfalls timely in order to devise strategies to address them.
- Develop an application capable of addressing the issue put forth on the problem statement.

The Waterfall model proved to be the most appropriate to capture this dynamic of concerns. Its ability to lock an accomplishment before proceeding ahead is appealing; however because there was also the issue of this methodology not accommodating backtracking, a tailored hybrid model was better suited. This hybrid methodology adds an agile development component to combine an iterative model

and an incremental building model for development which permits an evolutionary acquisition of results while refining the functionality of the design.

A standardized example of the implementation of such methodology in software development projects is referenced by the 1985 DOD-STD2167 (section 4.1.2), which states "*During software development, more than one iteration of the software development cycle may be in progress at the same time*". This process is described as an incremental building approach and the software process employed is what ultimately establishes the connection between iterations and increments.

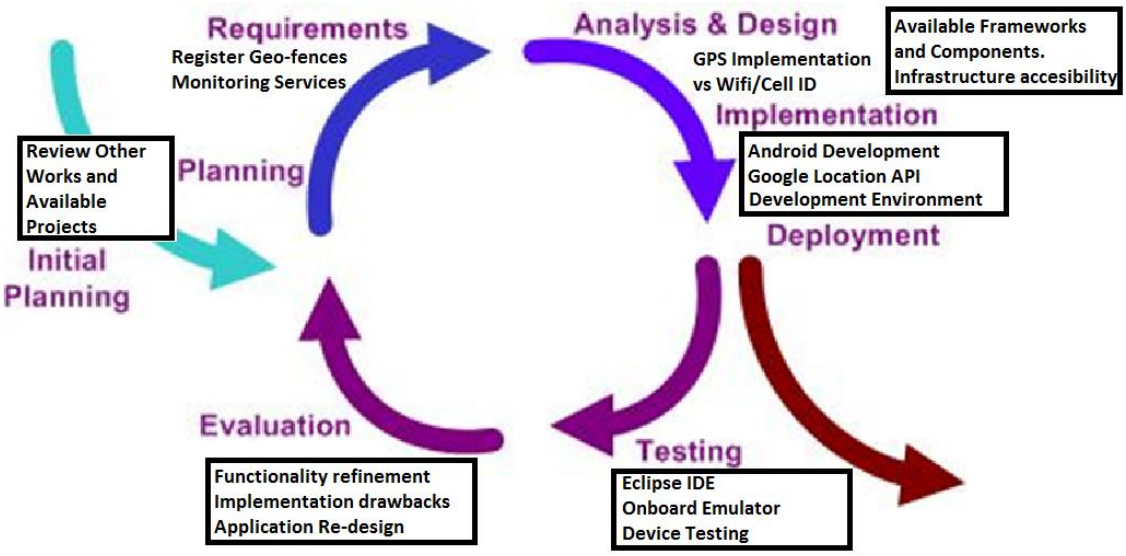


Figure 1 Iterative\Incremental Development Methodology

As the diagram demonstrates, the project work involved activities conducted in a cycle of continuous development and assessment, to permit both the project variables and outcomes to be refined for feasibility.

Project Gant Chart and Activities

ID	Task Name	Start	Finish	Duration	Q4 13		Q1 14		
					Nov	Dec	Jan	Feb	Mar
1	Research Stage -investigate particulars of geo-fencing tech. -Explore geo-fencing setup and implementations -Further the Literature Review	10/30/2013	11/19/2013	3w					
2	Design and Modeling -Define the conceptual design -Review extensively the architectural models and interactions between components -UML diagramming -UI designs and application concept -VIVA (FYP 1) [December 4th] -Interim Report Submission	10/30/2013	11/29/2013	4.5w					
3	Development -Join Developer Community forums -Install SDKs -Review available APIs and standards ...	11/29/2013	2/6/2014	10w					
4	Testing (Review and integrate developed modules, conduct system testing and few mutation tests)	2/6/2014	2/17/2014	1.5w					
5	Implementation/Deployment (Depending on applicability, deploy the application on the market)	2/13/2014	3/3/2014	2.5w					
6	Reporting -Record progress -Report progress to supervisor	11/7/2013	3/25/2014	19.8w					

Figure 2 Project Original Gant Chart

Prototyping Timeline Analysis

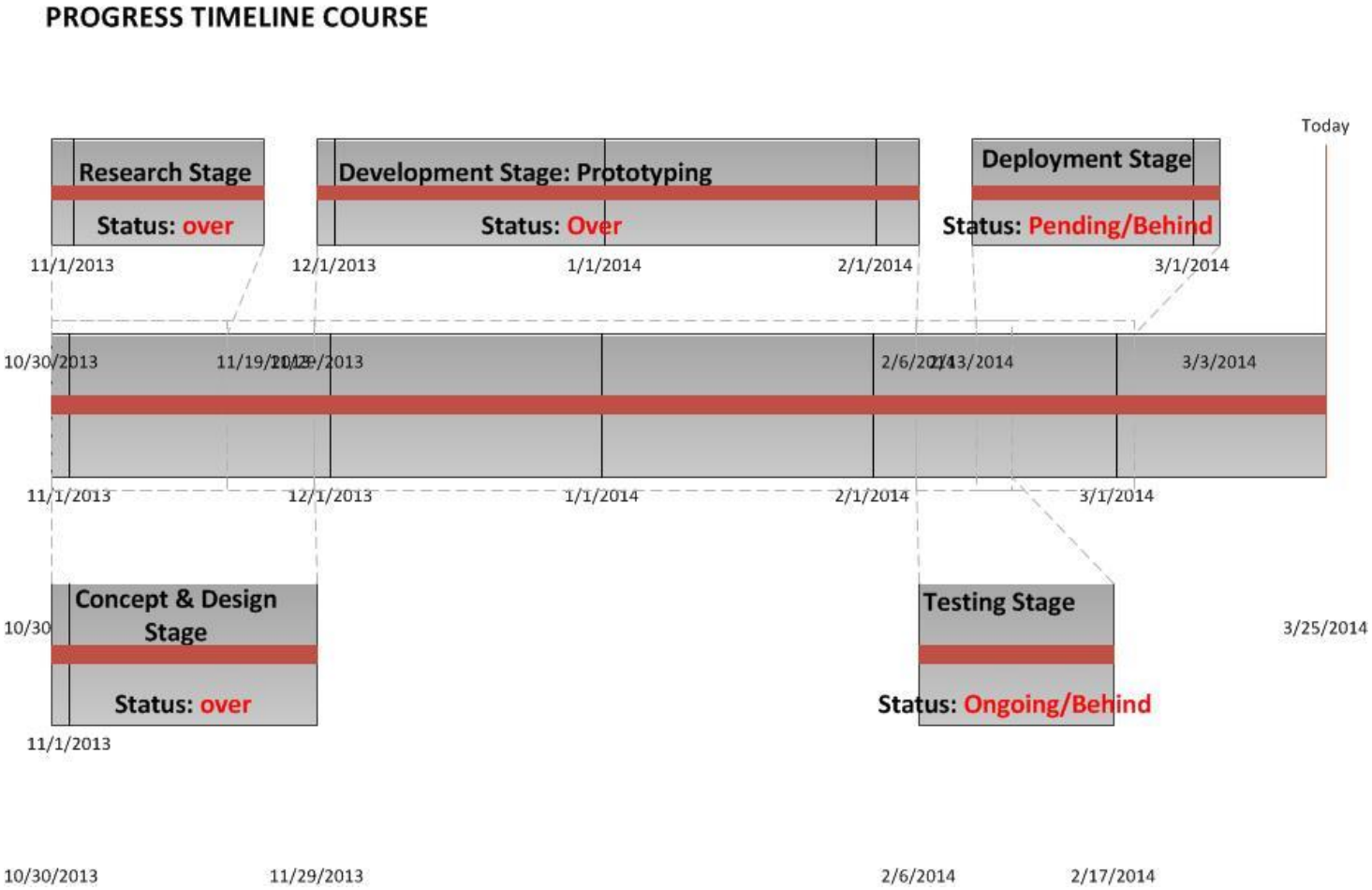


Figure 3 Timeline Of Project Progress

Project Research Stage

During this stage the most important directives were to figure out particular aspects of the geo-fencing technology itself, the available modules, which scenarios are applicable for mobile phones and particularly the development efforts concerning the android development platform.

The results achieved from the research stage were the workings uncovered through the Google APIs, private implementations undertaken by industry developers. However the most impact was delivered through the implementations suggested on diverse open collaboration projects on the web.

This aspect associated to the facts uncovered in the literature review assisted in constructing a background for the concept of the application and consequently gave way to the design stage.

Concept and Design Stage

The proposed system concept is designed to serve a universe composed by two (2) groups of users, to which I shall refer as primary and secondary for the purpose of discussion. The primary users have the ability to create and setup geo-fences; they are required to provide unique identifiers to which their geo-fences will be tied to. The unique identifiers will ensure than only the right user is authorized to edit and manage the geo-fence settings defined upon creation. The identifier is used for the sole purpose of referring geo-fences to their owners. The secondary users which are not required to have an ID, are those at the consumption end, they are provided with a facility to subscribe to existing geo-fences and get notifications or receive content associated with a particular geo-fence.

The highlight of the creation of geo-fences module is that apart from allowing the user to do the customary which is supplying a name, identifier and reach & location of the geo-fence it defines the event trigger and action to follow. On this course the

users subscribed to that geo-fence receives content defined by the primary user of that geo-fence, this allows for the servitude of the geo-fencing arrangement. The remaining sections of the application are the geo-fence management and notifications; the geo-fence management reserves two (2) sets of option tailored to each class of user. For the primary user the options to Edit, Disable or Delete a Geo-fence, and for the secondary user the options to search (valid for geo-fences declared public), subscribe or unsubscribe. However the system makes no exclusive restriction about one user employing both roles (primary and secondary), therefore there should not be any impediment against a user doing so, provided the user has an ID to be allowed to create geo-fences.

As for the notification section of the application, it should provide an Inbox like view of the notifications, wrapped under their respective geo-fence tag names; under this scenario notifications would be presented on an historical scrollable content view. The latest directive makes the indirect provision that the notification section of the application is inactive for a user that has not subscribed to a geo-fence.

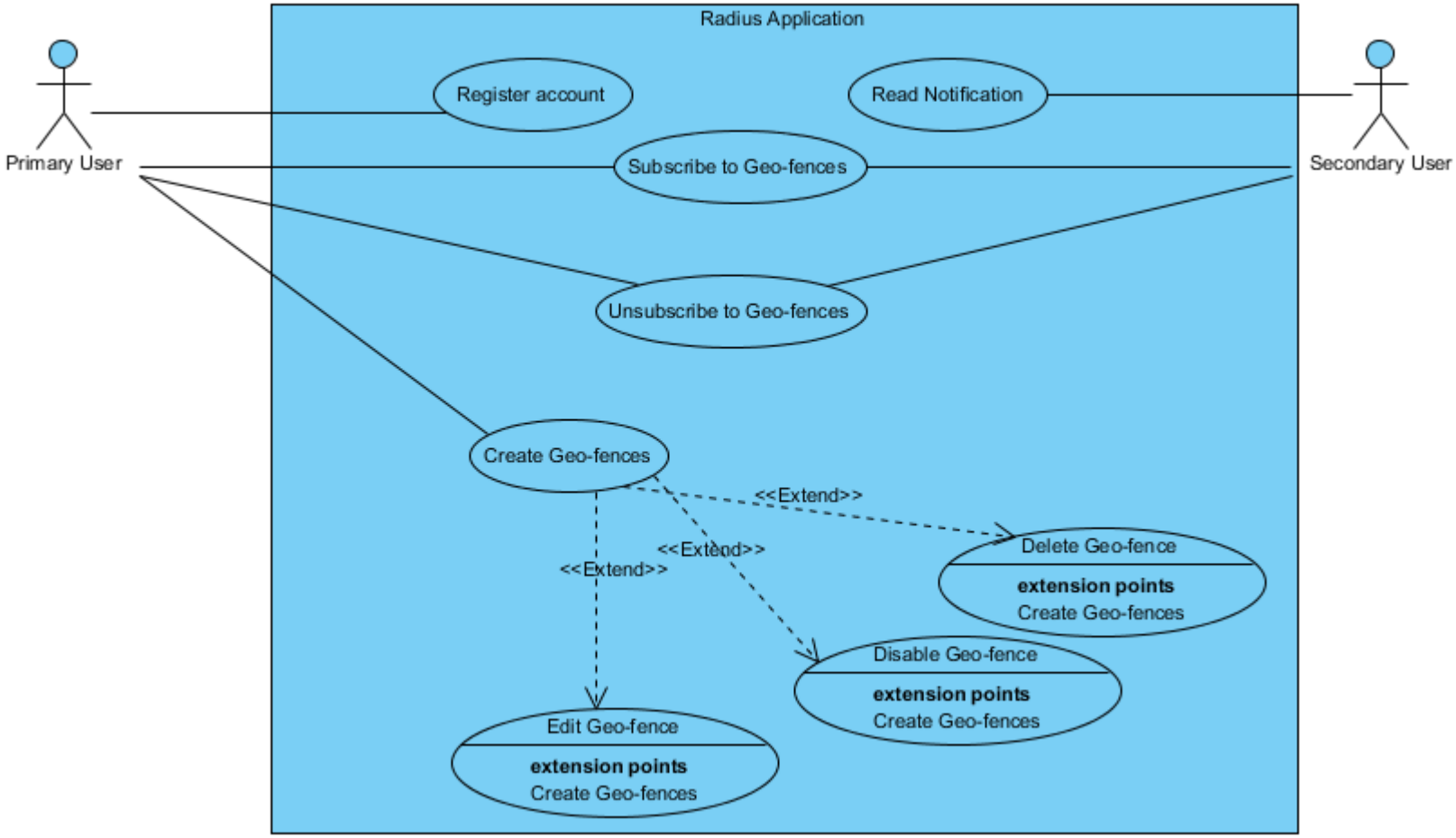


Figure 4 Application use case diagram for Primary and Secondary Users

Prototyping Stage

This stage presents the most demanding effort given the novelty of the concepts and tools in android development. Given the limited exposure and time constraint, instead of the conventional approach of procedural learning of development, the focus was on reviewing any workings that pertain to the concepts that the application observes in order to target the learning efforts to the modules.

Thus far the major aspects uncovered are:

- UI [programming the features]
- Geo-fence features [few modules available]
- Application Message Passing
- All Communication & protocols
- Integration

Android Operating System Platform

Android has in the recent years grown into the most prominent mobile operating system and, along with its popularity it has also developed in the capability of services and tools offered to developers. These efforts translate in a massive undertaking of projects and collaborations (Open Source) that allow barriers to be traversed and ambitious project to become real.

The main advantage the android platform offers is the ready comprehension with Google serving APIs and relatively cheap access to resources. This comes at a bargain if we consider the potential Google's network offers to deliver application on a global scale.

GOOLE CLOUD MESSAGING

The Google android push messaging platform which has become the main option for delivery of mobile content not only because its cost appeal but because of readily available content delivery supported by the Extensive Messaging Presence Protocol (XMPP). This standard provides a mechanism for communicating with applications through the cloud, allowing content on servers to be synced to the application on users devices.

The Cloud to Device Messaging (C2DM) service is the most forward servicing option offered by google, it allows applications to update their content even in the idle state, waking up the application when new messages are made available. The limitation of the C2DM messaging service is its imposition to keep messages short. However this serves the purpose to allow users to be notified of new content available for download.

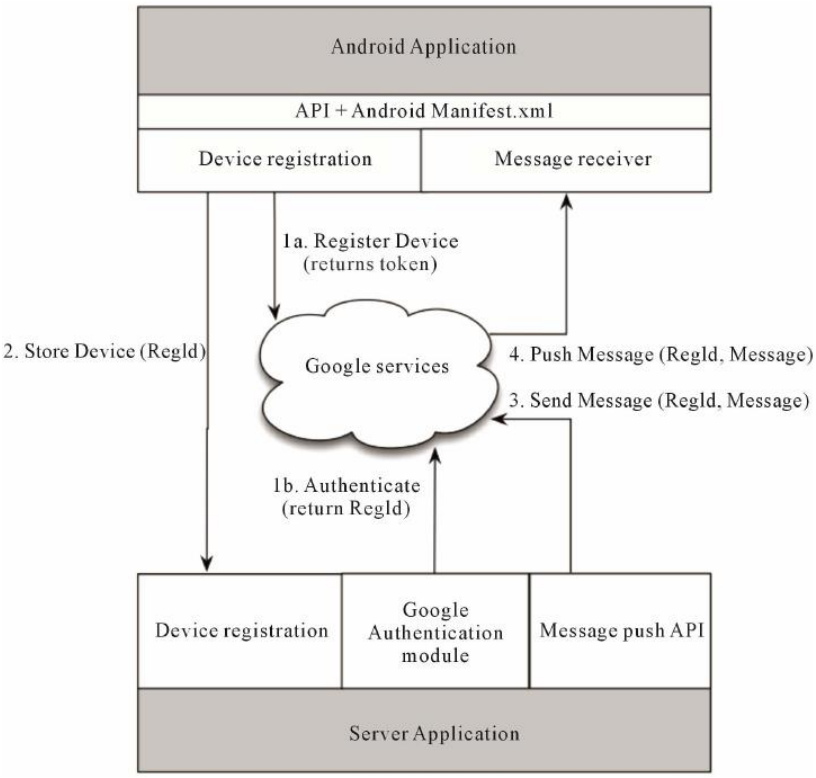


Figure 5 schematic for Google Cloud Messaging Content Delivery

GOOGLE LOCATION SERVICES

Google's location sourcing technologies are based on multiplicity of connectivity techniques such as cell tower triangulation, Wifi MAC address, GPS assisted location among the most prominent. The relative success with which google was able to establish its google maps application paved the way for the establishment of its location infrastructure as the main standard in providing location services.

Chapter 5

System Architecture

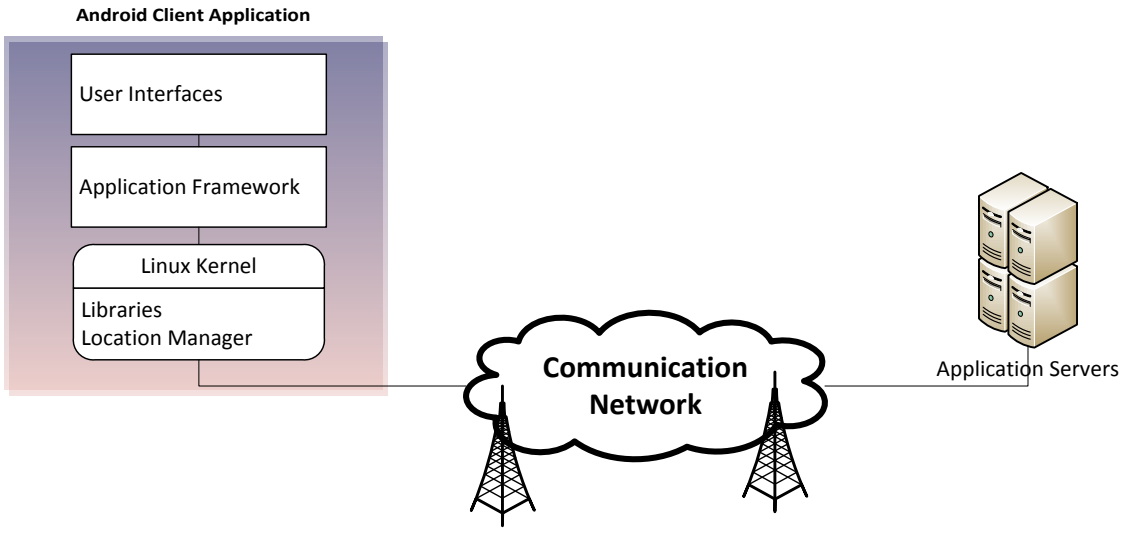


Figure 6 Device perspective implementation

The general outline of the application architecture is divided into the device level implementation and infrastructure level, the infrastructure level implementation referred to at this stage is abstract. The application servers are presented as servicing units that provide immediate application centered services like the authentication of users and interfacing for content retrieval and delivery.

The system operating cycle requires the location of the user to be a parameter in providing the service therefore positioning technologies are a predominant factor of the architecture. The application operates under event triggered constraints therefore availability of the modules to determine the conditions of the events are a priority. The system defines as priority the ability to authenticate users and define their location so that positioning data is available upon service requests. To support the availability of the user's location, the application framework interacts with the location manager which communicates with the onboard sensors.

On an infrastructural level once the client request has been received and authenticated (requests sent using Google Cloud Messaging) the system relies on the location servers to read the location data and determine the status of the device. The application also relies on content providers to deliver the notification and messages.

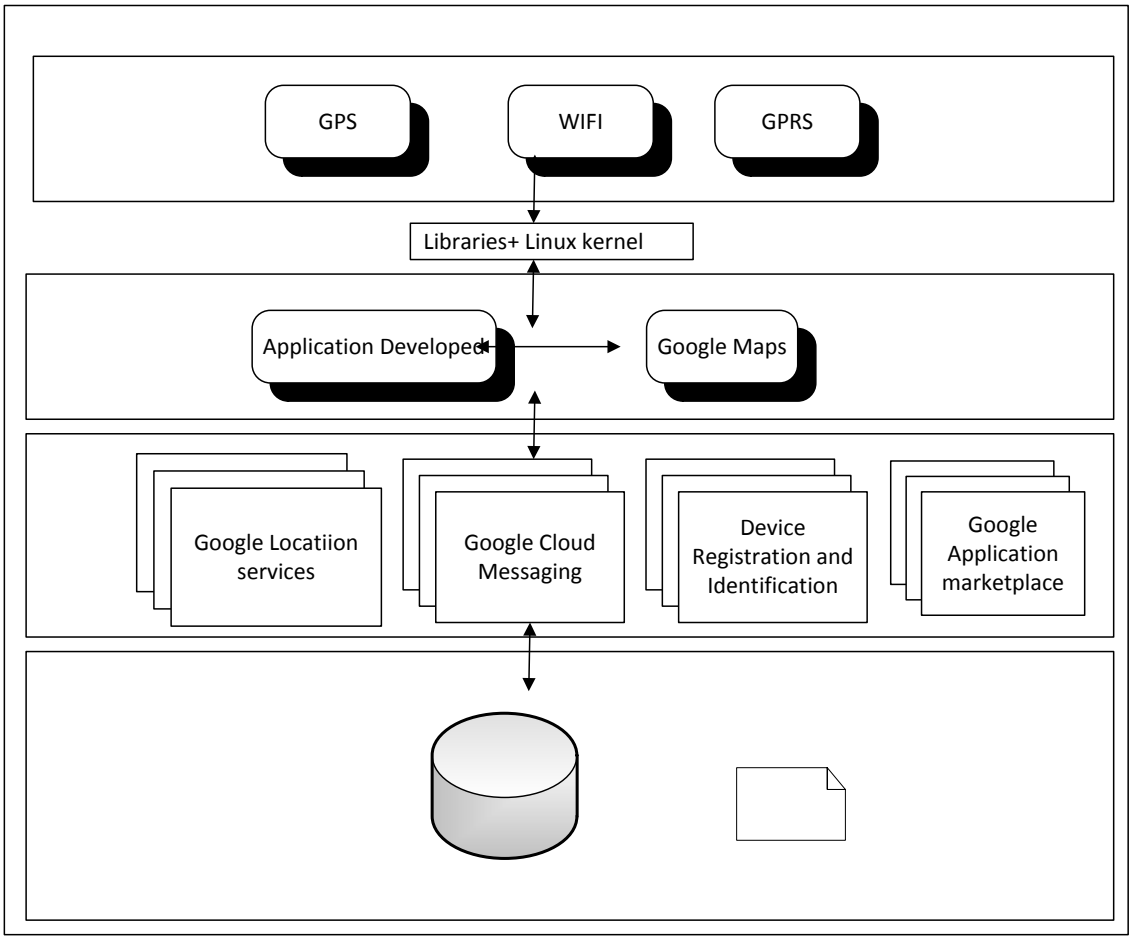


Figure 7 Framework for the project implementation

System Architecture

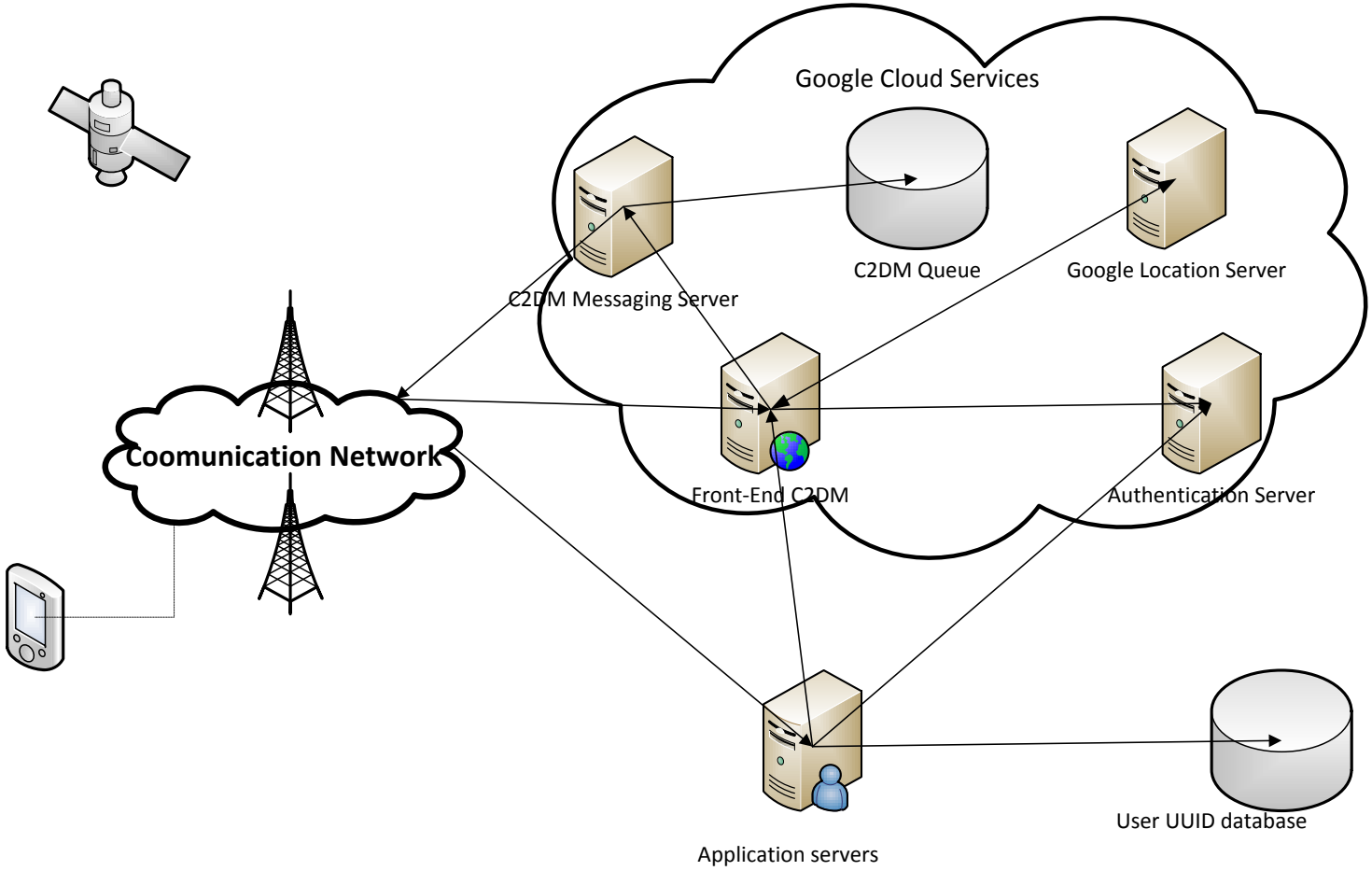


Figure 8 Overall View Of Application Architecture and components

Chapter 6

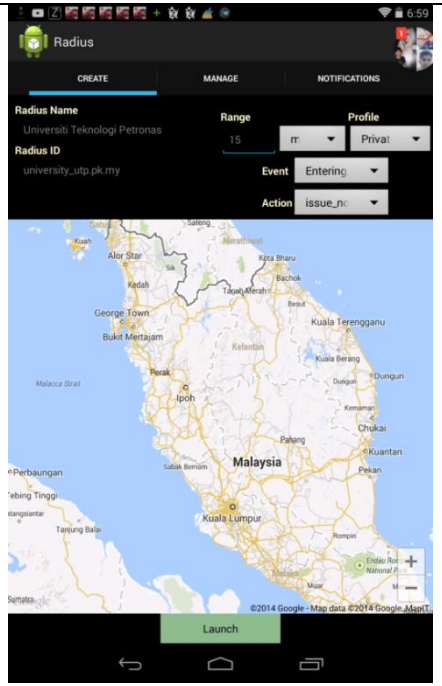
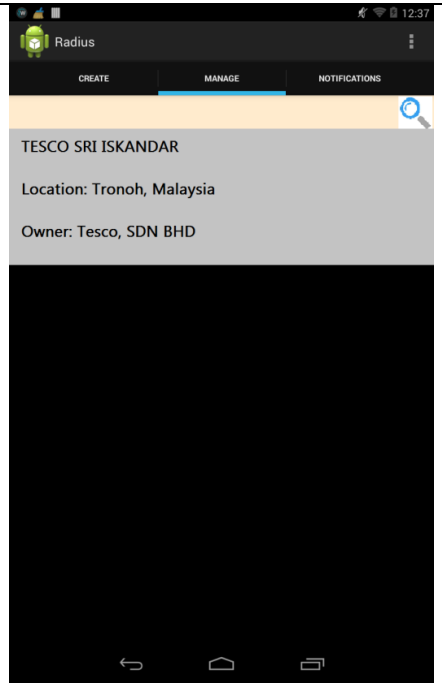
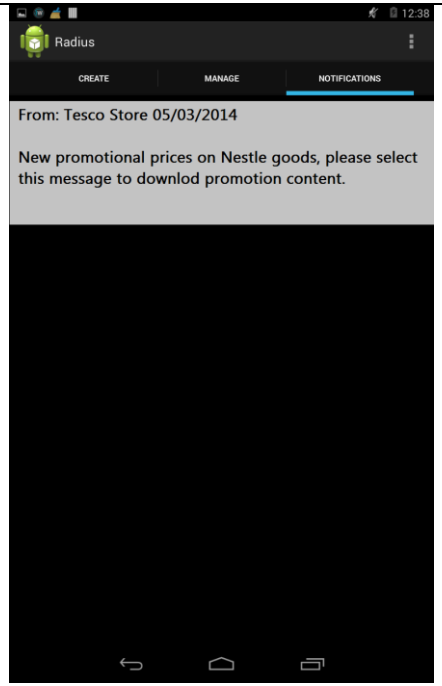
Discussion Case

Taking the case study of how local concept stores run their advertising through internal managed company loyalty programs, and ask users to provide phone numbers in order to provide them with promotional services, we immediately gather a discussion case for evaluating the application usefulness.

The issue with the current method employed by concept stores which is mainly network based; customer that have logged their phone numbers a region upon filing for a shopping card get promotional messages. The problems with this module are, apart from the fact that customer may move or change their numbers, and they also may find this type of advertising to be invasive. These reasons are in the least aspects given that sms based presentation is very constrained in terms of the content that is delivered and therefore there is low appeal of the promotional content being transmitted.

Application Walkthrough

Table 1 Application Design Walkthrough

TAB: create Geo-fences	**TAB:** Manage Geo-fences	**TAB:** Notifications
		
User fills geo-fence details and selects and a location and radius for the content to be delivered. User will receive content as they are in referred range.	The Geo-fences the user has subscribed/created are displayed and options are displayed on click. Additionally a search bar is provided.	The notifications are displayed for users who have subscribed for a particular geo-fence.

Results

The application would address most of the difficulties identified with the current procedure on the discussion case; since it would not be network based, meaning it would not require collecting phone numbers we eliminate the possibility of advertising to the wrong domains.

On the other hand, since use are given the preemptive choice to subscribe to the geo-fences, advertising can be delivered in a non-invasive manner, user will actively select the content they intend to receive by subscribing to geo-fences of their interest. On another note customer privacy is preserved because the system does not require customer to log their information, the application only operates as their personal books of location interest for which content is delivered.

Lastly but not least slick and minimalistic notifications are delivered to customer to give them a note of new promotional events and customers reserve the convenience to download a full advert.

Conclusion and Recommendations

Conclusion

The application usability potential is presented against a discussion case which is tailored to expose the applicability of the model in terms of providing non-invasive advertising services and is proved to be usable given the low requirements it imposes on client information.

Additionally, since the application was developed using Google's application infrastructure it can be made usable on a worldwide scale context, which reassures the power the application presents in terms of delivery capability. Furthermore the project objective to provide a proximity based service network by leveraging on geo-fencing was upheld reassuring the validity of the generic concept of the application.

Recommendations

The opportunities for further work in terms of the project's validity of concept can be explored by creating a study in the regional community after the first prototype is released to determine the usability traits of the application This measure can also be an effective strategy in gathering further application scenarios for the application that would assist in constructing a concrete tool that can be turned into useful product.

Another important recommendation is the extension of the application further so that geo-fences and content can be delivered taking into account timing and periods so as to maximize the users' convenience. The premises for use of a system of nature to employ as a patient information system are also put forth for consideration.

Bibliography

[1] A. Küpper, U. Bareth and B. Freese, "Geofencing and Background Tracking – The Next Features," *Informatik schafft Communities,* 2011.

[2] A. Boukerche, H. Oliveira, E. Nakamura and A. Loureiro, "Vehicular Ad Hoc Networks: A New Challenge for Localization-Based Systems," *ELSEVIER (Science Direct),* 2008.

[3] R. Rajachandrasekar, Z. Ali, S. Hedge and V. Meshram, "Location-Based Query processing: Sensing our Surroundings," 2011.

[4] B. Jeon and R. C. K. Young, "A System for detecting the Stray of Objects within User-defined Region using Location-Based Services," *International Journal of Software Engineering and Its Applications,* vol. 7, no. 5, pp. 355-362, 2013.

[5] D. Namiot and M. Sneps-Sneppe, "Geofence and Network Proximity," 2012.

[6] W.-J. Yi and S. J., "System Architecture and Design Flow of Smart Mobile Sensing Systems," *Journal of Sensor Technology,* pp. 47-56, 2013.

[7] P. Shah, R. Gadgil and N. Tamhankar, "Location Based Reminder Using GPS For Mobile (Android)," *ARPN Journal Of Science and Technology,* vol. 2, 2012.

[8] Y. Qu and J. Zhang, "Trade Area Analysis using User Generated Mobile Location Data," 2012.

[9] T. NAKAGAWA, W. YAMADA, C. DOI, H. INAMURA, K. OHTA and M. SUZUKI, "Variable Interval Positioning Method for Smartphone-Based Power-saving Geofencing".

[10] A. C. Ijeh, D. S. Preston, C. O. Imafidon, T. Watmon and A. Uwaechie, "Geofencing Components and Existing Models," *Proceedings of the International MultiConference of Engineers and Computer Scientists,* vol. II, 2010.

[11] A. Ijeh, A. J. Brimicombe, D. Preston and C. Imafidon, "Evaluating Ethical and Productivity Issues in Geofencing," *Symposium on Progress in Information & Communication Technology 2009,* 2009.

[12] D. Huber, "Background Positioning for Mobile Devices - Android vs iPhone," 2010.

[13] M. Calder, X. Fan, Z. Hu and e. al, "Mapping the Expansion Of Google's Serving Infrastructure," 2013.

[14] E. Burnette, Hello, Android: Introducing Google's Mobile Development Platform, Pragmatic Bookshelf, 2010.

[15] S. Ahson and I. M., Mobile Web 2.0: Developing and Delivering Services to Mobile Devices, CRC Press, 2011.

APPENDIX

AN ANDROID GENERIC GEO-FENCING APPLICATION: PROXIMITY TRIGGERED NOTIFICATION SERVICE DELIVERY

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ABSTRACT

This documentation proposes the design of an android based software application that makes use of Geo-fencing. Geo-fencing is software program feature that enables the use of GPS and RFID capability to define a virtual perimeter around a "hotspot" and trigger event notifications (as 'people-devices' move into or out of the established perimeter). Immediate examples of the application of geo-fencing range from its use in supporting mobile based market campaigns, under a scenario where customers would receive offers granted their proximity of a place of interest; providing regional informational services which can support health and safety campaigns for users on a certain regional context; to more particular uses such as home monitoring activities etc.

Keywords: Application, Concept, Geo-fence, perimeter monitoring, location based service (LBS)

INTRODUCTION

The technological revolution in the communication industry has allowed for ordinary smart mobile phones to be equipped with advanced global positioning and radio frequency identification hardware. This advance sets a whole new precedence for the application opportunities that can be derived using location based services. While as mentioned this devices are equipped with the most advanced positioning software there is still the issue of having capable user tuned software to make use of this features. The native mobile phone software only covers the most basic usability features and it is up to third party developers to make use of the SDKs of the different mobile OS to produce quality software capable of extending the capability of these devices and deliver that potential to users. Therefore this project presents the concept; the development effort and the working methodology employed on the course of the project. The Main remark of this report is the architectural and conceptual models proposed for the software application.

SCOPE OF PROJECT

Globalization has had a profound impact on the way businesses address customers and the array of services they provide. The increased competitiveness and thus availability of options has led customers to judge business not only by the quality of their products but also by the

convenience with which services reach them.

In modern advertising, the popularity and appeal of social networking tools has caught the interest and eye of advertisers given the potential to reach a large customer base, nevertheless the matter of advertising sound equipment to a deaf user is still an item. A more targeted delivery is obtained by harvesting customers' cookie data, but this is often associated with invasion of customer's privacy. These developments expose the need for a non-evasive ad targeting mechanisms that tailors to customer's interest.

OVERVIEW OF LOCATION BASED SERVICES

The up and coming generation of location services is supported by mobile devices that almost effortlessly determine the whereabouts of the user, that has contributed significantly to improve the developments in this area [1]. However, it is important to mention that these technologies (GPS) also bear significant drawbacks, such as the inefficacy when indoors, latency of first positioning (Time-to-First Fix, TTFF) and the power consumption constraint. In order to overcome this shortcomings device manufacturers' employ hybrid positioning technologies made of a combination of GPS, Wi-Fi and Cell-Id to broaden the capability spectrum of the positioning hardware (Küpper, Bareth, & Freese, 2011). In order to support the contextual evaluation of this service on the course of the paper the following terminologies are clarified.

- **Latency**, the time required to obtain a fix of the user's location, also referred as Time to first Fix (TTFF) in GPS positioning's case.
- **Battery drainage** refers to the relative power consumption shortcoming of mobile phones when employing intensive positioning services.
- **Geographical domain**, a comprehensive perimeter around a physical location of interest.
- **Location Dependent Data**, relates to information relayed based on the parameter defined by the user's location.

This capability spectrum of positioning technologies results in classification of location based services according to the precision and intensiveness of object's positioning. This classification separates applications that fall under the purview of active service mechanism which covers services such as navigation, location tracking; and passive service mechanism which covers services such as checking whether an object has left a certain geographical domain once expired an assigned timestamp [2].

Geo-fencing hence falls under the classification of passive service mechanism location based services; and its main application is centered in determining the drifting status of an object within a user-specified geographical domain meaning events are triggered simply by detecting whether the object has entered, or exited a virtual fence. Once the desired/undesired event has occurred a notification is issued to the user to alert them that the event has occurred. The possibility of geo-fence implementations keeps expanding and as new applications and services are added to the location based standards the more flexible the services tend to

become. The increasing prospects of analogous implementations of this location services paradigm are rapidly unifying into a concrete library/platform that leverages on Google's cloud services and fueled by a large community base development, A further boost into geo-fencing services can be gained from coupling the geo-fence application/program with Google Cloud Messaging (GCM) to enable data to be sent from the servers to applications on android mobile phones; or alternatively a similar service could be used for iPhone users Apple Push Notification (APN).

BACKGROUND AND METHODOLOGY

In devising a prototype solution for the development of the software application that will address the goal of producing a generic concept application, few compromises are recognized. This compromises concern platform implementation aspects and not the core of the envisioned system therefore the results to be achieved shall remain valid to be applied to other equally resourceful platforms and execution paradigms. The chief positioning method taken into consideration in establishing the subject's status is Global positioning Service (through satellite support), although in reality mobile phones employ a multitude of hybrid settings.

Concerning the infrastructure for the system, Google's platform is undeniably the best servicing option considered its global network, access to managed services and development support apart from its capability to serve different mobile operating systems therefore the mapping services are based on google maps. The location collection service under Google's umbrella provide for the location provider and geocoding facilities which interface with the devices onboard location manager. The Android OS, provides readily available developer knowledge base and an open development paradigm, this contributes so that third party developers are enabled to provide compatible additional libraries that further extend the servicing options of Google Maps.

A planning framework to ensure that at every stage of the project, the structure and control process can easily be addressed is defined using module oriented development. This results in the subdivision of the projects modules in the following, User Interface Design, Location representation services supported by Google Maps, communication interfaces and Google Cloud Messaging. The discipline to adhere to that skeleton is was the source for consistency along the project and guaranteed a successful outcome in terms of the functionalities that would demonstrate the extent of geo-fencing application.

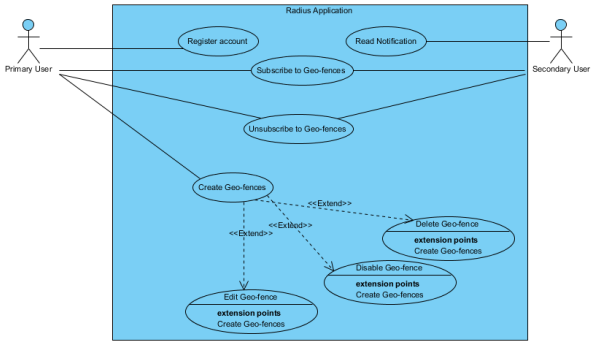
PROPOSED SYSTEM CONCEPT

The proposed system concept is designed to serve a universe composed by two (2) groups of users, to which we shall refer as primary and secondary for the purpose of discussion. The primary users have the ability to create and setup geo-fences; they are required to provide unique identifiers to which their geo-fences will be tied to. The unique identifiers will ensure than only the right user is authorized to edit and manage the geo-fence settings defined upon creation. The identifier is used for the sole

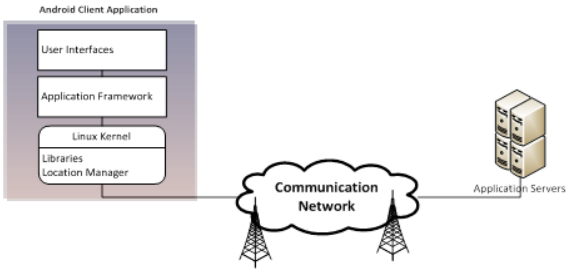
purpose of referring geo-fences to their owners. The secondary users which are not required to have an ID, are those at the consumption end, they are provided with a facility to subscribe to existing geo-fences and get notifications or receive content associated with a particular geo-fence.

The highlight of the creation of geo-fences module is that apart from allowing the user to do the customary which is supplying a name, identifier and reach & location of the geo-fence it defines the event trigger and action to follow. On this course the users subscribed to that geo-fence receives content defined by the primary user of that geo-fence, this allows for the servitude of the geo-fencing arrangement. The remaining sections of the application are the geo-fence management and notifications; the geo-fence management reserves two (2) sets of option tailored to each class of user. For the primary user the options to Edit, Disable or Delete a Geo-fence, and for the secondary user the options to search (valid for geo-fences declared public), subscribe or unsubscribe. However the system makes no exclusive restriction about one user employing both roles (primary and secondary), therefore there should not be any impediment against a user doing so, provided the user has an ID to be allowed to create geo-fences.

As for the notification section of the application, it should provide an Inbox like view of the notifications, wrapped under their respective geo-fence tag names; under this scenario notifications would be presented on an historical scrollable content view. The latest directive makes the indirect provision that the notification section of the application is inactive for a user that has not subscribed to a geo-fence.



SYSTEM ARCHITECTURE AND COMPONENTS



The general outline of the application architecture is classified into the device level implementation and infrastructure level, the infrastructure level implementation referred to at this stage is abstract. The application servers are presented as servicing units that provide immediate application centered services like the authentication of users and interfacing for content retrieval and delivery.

The system operating cycle requires the location of the user to be a parameter in providing the service therefore positioning technologies are a predominant factor of the architecture. The application operates under event triggered constraints therefore availability of the modules to determine the conditions of the events are a priority. The system defines as priority the ability to authenticate users and define their location so that positioning data is available upon service requests. To support the availability of the user's

location, the application framework interacts with the location manager which communicates with the onboard sensors.

On an infrastructural level once the client request has been received and authenticated (requests sent using Google Cloud Messaging) the system relies on the location servers to read the location data and determine the status of the device. The application also relies on content providers to deliver the notification and messages.

ANDROID OPERATING SYSTEM PLATFORM

Android has in the recent years grown into the most prominent mobile operating system and, along with its popularity it has also developed in the capability of services and tools offered to developers. These efforts translate in a massive undertaking of projects and collaborations (Open Source) that allow barriers to be traversed and ambitious project to become real.

The main advantage the android platform offers is the ready comprehension with Google serving APIs and relatively cheap access to resources. This comes at a bargain if we consider the potential Google's network offers to deliver application on a global

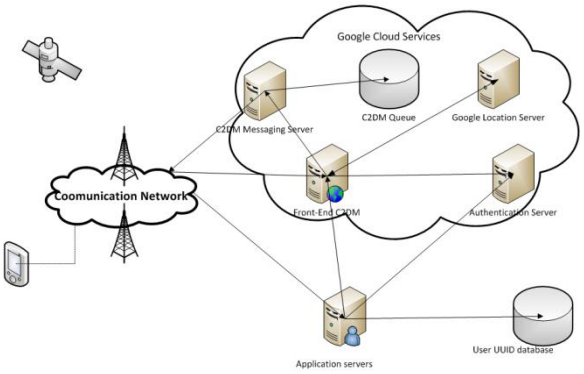
GOOLE CLOUD MESSAGING

The Google android push messaging platform which has become the main option for delivery of mobile content not only because its cost appeal but because of readily available content delivery supported by the Extensive Messaging Presence Protocol (XMPP). This standard provides a mechanism for communicating with applications through the cloud, allowing content on servers to be synced to the application on users devices.

The Cloud to Device Messaging (C2DM) service is the most forward servicing option offered by google, it allows applications to update their content even in the idle state, waking up the application when new messages are made available. The limitation of the C2DM messaging service is its imposition to keep messages short. However this serves the purpose to allow users to be notified of new content available for download.

GOOGLE LOCATION SERVICES

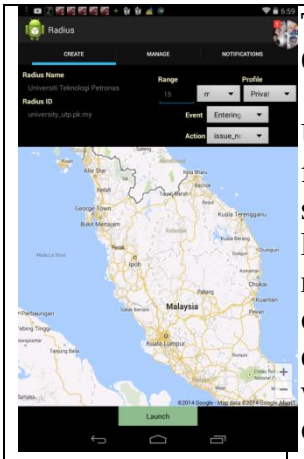
Google's location sourcing technologies are based on multiplicity of connectivity techniques such as cell tower triangulation, Wifi MAC address, GPS assisted location among the most prominent. The relative success with wich google was able to establish its google maps application paved the way for the establishment of its location infrastructure as the main standard in providing location services.



DISCUSSION CASE

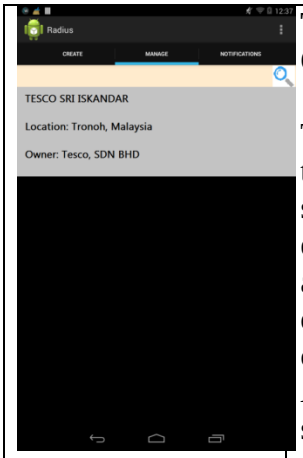
Taking the case study of how local concept stores run their advertising through internal managed company loyalty programs, and ask users to provide phone numbers in order to provide them with promotional services, we immediately gather a discussion case for evaluating the application usefulness.

The issue with the current method employed by concept stores which is mainly network based; customer that have logged their phone numbers a region upon filing for a shopping card get promotional messages. The problems with this module are, apart from the fact that customer may move or change their numbers, and they also may find this type of advertising to be invasive. These reasons are in the least aspects given that SMS based presentation is very constrained in terms of the content that is delivered and therefore there is low appeal of the promotional content being transmitted.



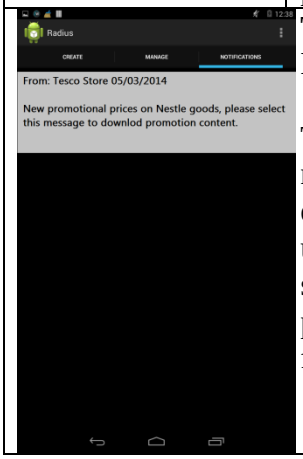
TAB: create Geo-fences

User fills geo-fence details and selects and a location and radius for the content to be delivered. User will receive content as they are in referred range.



TAB: Manage Geo-fences

The Geo-fences the user has subscribed/created are displayed and options are displayed on click. Additionally a search bar is provided.



TAB: Notifications

The notifications are displayed for users who have subscribed for a particular geo-fence.

RESULTS

The application would address most of the difficulties identified with the current procedure on the discussion case; since it would not be network based, meaning it would not require collecting phone numbers we eliminate the possibility of advertising to the wrong domains.

On the other hand, since use are given the preemptive choice to subscribe to the geo-fences, advertising can be delivered in a non-invasive manner, user will actively select the content they intend to receive by subscribing to geo-fences of their interest. On another note customer privacy is preserved because the system does not require customer to log their information, the application only operates as their personal books of

location interest for which content is delivered.

Lastly but not least slick and minimalistic notifications are delivered to customer to give them a note of new promotional events and customers reserve the convenience to download a full advert.

RECOMMENDATIONS

The opportunities for further work in terms of the project's validity of concept can be explored by creating a regional study after the first stable release to uncover further usability scenarios for the application. This measure can be an effective strategy in constructing a concrete tool that can be turned into useful product.

As for the project resources and materials, further development and assessment can be conducted to evaluate the architecture implementation to cover other more power efficient application modules such as making cell-ID and Wi-Fi MAC address the primary mechanisms to determine a user's geographical domain.

In terms of the application concept the application of scheduling could lead to a more solid product design in terms of accounting for effectiveness of use of mobile phone resources by wireless technologies. Timing could also be applied to further enhance the geo-fencing services to account for time variables.

CONCLUSION

In this paper we discuss the applicability of geo-fencing to design a concept for a generic software application that makes use leverage on Google's servicing infrastructure to provide perimeter monitoring services widely available.

Further we also, propose recommendations to improve its usability and operational features by suggesting the inclusion and study of algorithms to streamline power consumption and overall mobile resources allocation.

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References

[1] A. Küpper, U. Bareth and B. Freese, "Geofencing and Background Tracking – The Next Features," *Informatik schafft Communities,* 2011.

[2] B. Jeon and R. C. K. Young, "A System for detecting the Stray of Objects within User-defined Region using Location-Based Services," *International Journal of Software Engineering and Its Applications,* vol.

7, no. 5, pp. 355-362, 2013.

[3] W.-J. Yi and S. J., "System Architecture and Design Flow of Smart Mobile Sensing Systems," *Journal of Sensor Technology,* pp. 47-56, 2013.

[4] P. Shah, R. Gadgil and N. Tamhankar, "Location Based Reminder Using GPS For Mobile (Android)," *ARPN Journal Of Science and Technology,* vol. 2, 2012.

[5] R. Rajachandrasekar, Z. Ali, S. Hedge and V. Meshram, "Location-Based Query processing: Sensing our Surroundings," 2011.

[6] Y. Qu and J. Zhang, "Trade Area Analysis using User Generated Mobile Location Data," 2012.

[7] D. Namiot and M. Sneps-Sneppe, "Geofence and Network Proximity," 2012.

[8] T. NAKAGAWA, W. YAMADA, C. DOI, H. INAMURA, K. OHTA and M. SUZUKI, "Variable Interval Positioning Method for Smartphone-Based Power-saving Geofencing".

[9] A. C. Ijeh, D. S. Preston, C. O. Imafidon, T. Watmon and A. Uwaechie, "Geofencing Components and Existing Models," *Proceedings of the International MultiConference of Engineers and Computer Scientists,* vol. II, 2010.

[10] A. Ijeh, A. J. Brimicombe, D. Preston and C. Imafidon, "Evaluating Ethical and Productivity Issues in Geofencing," *Symposium on Progress in Information & Communication Technology 2009,* 2009.

[11] D. Huber, "Background Positioning for Mobile Devices - Android vs iPhone," 2010.

[12] M. Calder, X. Fan, Z. Hu and e. al, "Mapping the Expansion Of Google's Serving Infrastructure," 2013.

[13] E. Burnette, Hello, Android: Introducing Google's Mobile Development Platform, Pragmatic Bookshelf, 2010.

[14] A. Boukerche, H. Oliveira, E. Nakamura and A. Loureiro, "Vehicular Ad Hoc Networks: A New Challenge for Localization-Based Systems," *ELSEVIER (Science Direct),* 2008.

[15] S. Ahson and I. M., Mobile Web 2.0: Developing and Delivering Services to Mobile Devices, CRC Press, 2011.