Trading-off immediacy and trustworthiness in participatory sensing

by

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A dissertation submitted to the University of Dublin, Trinity College,

In partial fulfilment of the requirements for the degree of

Master of Science in Computer Science.

(Mobile and Ubiquitous Computing)

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August 2013

Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

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Acknowledgment

I would like to thank my dissertation supervisor, Dr. Melanie Bouroche for all her contribution, guidance and encouragement during the process of my dissertation. Dr. Melanie Bouroche was supported and enthusiastic all the time and I could not accomplish my dissertation without her assistance.

In a more personal note, I would like to express my gratitude to my family for their support throughout this year.

Abstract

Traffic congestion is an important issue that many development cities suffering from. This project is based on participatory sensing that exploits the power or the crowd. Through the mobile application the citizens will be aware for the real situation in the streets and simultaneously will be able to report traffic incidents that citizens can view. It is noticed that other similar applications delay to publish the reports. They are waiting from other users to confirm it. The dissertation focuses on making the publication of traffic reports faster while allowing the users to evaluate the trustworthiness of the reports.

The mobile application uses non-monetary rewards and rank methods to motivate users to participate and to empower them to publish traffic reports immediately. Extra information (percentage, username) is provided in each report that enables users to evaluate the trustiness of the reports. In case that the given information is not valuable for a specific report, the user has to wait until the “trustiness” equation to characterize the report as “trusted”. The “trustiness” equation should take into account four parameters (number of votes from users, time, location, population density), in order to work properly for each report. The results in the evaluation demonstrate that the mobile application is easy to learn and user-friendly. In many cases the extra information for the reports are useful to the users and they trust the report. Moreover, the results show that the “trustiness” equation should take into account all the parameters else the equation does not work properly under specific circumstances.

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Chapter 1

Introduction

Three decades ago, the initial idea as far as mobile phones were concerned was to develop devices which will be able to be connected in every place around the world, supporting only a few functionalities such as calls and text messages. During these decades, the capabilities of mobile phones are flourishing exponentially. Nowadays, mobile phones are equipped with high-performance processors, cameras, 3G technologies, Wi-Fi, sensors (temperature, humidity). These new capabilities and the low cost of production boost the people all over the world to own a mobile phone. Nowadays, the number of mobile subscriptions in the world is almost the same with the global population and they are expecting that in the next few years will surpass the overall population. The population of the world is seven billion and the subscriptions are approximately 5,981 billion*.

It is up to us to exploit correctly the consequences of this increasing trend. The most common aspect which can contribute to our daily social life is Crowdsourcing. The general idea relies on the following motto “millions of brains are better than one”. Because crowdsourcing is vague, many people have tried to give a definition to this idea. In this work we will based on the following definition. “*Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a*

* "Global mobile statistics 2012 Part A: Mobile subscribers; handset market share; mobile operators". *Mobithinking*. 9 August 2012

given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken"[1].The word comes from two different words crowd and sourcing. With simple words the idea is that given we have a problem/work, we take it and outsourcing it to the crowd. There are a lot of advantages behind this idea such as better quality results, quicker results, lower-cost [15]. Nowadays, the most common and well-known examples are Wikipedia, Youtube, Linux.

Participatory sensing, is a method which emphasis the involvement of citizens/users/stakeholders and community groups in the process of sensing and documenting where they live and work. The range of collaborating data ranges from personal individual observation to hundreds even thousands of individuals who collect data during their daily routine. From social point of view, Participatory Sensing commences and ends with people as individuals and members of community. In Participatory Sensing, the tools are used for gathering data vary. The tools should be devices such as surveillance cameras, home weather stations, mobile phones. Mobile phones have advantages compare to other devices that make them unprecedented tool for gathering data at any possible point of the earth. The main benefits against the other tools are the low-cost of implementation and the ubiquitousness of mobile devices [2]. Additionally, participatory sensing is about the systematic observation, study, reflection on and finally the sharing of information/data to the rest of the world.

From the two ideas above, a vast question generated. How will we persuade people to contribute in order to achieve the desirable result? There are plenty examples where the idea of volunteerism did not have the appropriate results. Participants need incentives. There are many encouragement and retention schemes. Firstly, we can provide ways to establish, show, and measure reputation /fame. Secondly, we can provide ownership situations where the participant feels he "owns" a part of the system and as a result is compelled to "cultivate" that part. Thirdly, we can provide a kind of instant gratification, by showing his contribution until the current moment

and the effect of his contribution to the whole system. Finally, we can provide, in parallel with the contribution, an enjoyable experience or necessary service, which will be addictive to the user, such as game playing [8] [22].

In this project, we will be focused mainly on reward and ranking methods. A simple example of this technique should be when a user publishes useful and validated information to the application then he will be rewarded for that [8].

Taking all the above factors into account, we will try to merge them all together in order to create a mobile application. The users will publish information concern with traffic in the roads. With this technique all the participants are aware of the current situation in the streets and they can act accordingly. It is noticeable that quite similar application delay to publish the information, because they are waiting from other users to confirm it. In this project, we focus on immediate reports while allowing users to evaluate the report's trustworthy.

With our new approach, we aim to address a well-known problem from which the biggest cities suffering from. Nowadays, Traffic jam is a big issue that different kinds of scientists strive to address. With our approach we will not solve the problem but we believe that we will contribute in order to improve the situation.

1.1. Project Motivation

The traffic jam phenomenon is a problem that makes me to think hard about it from very young age. I grew up in a city that is suffering from traffic congestion for more than twenty years. All of these years I had made many conversations with colleagues and professors about it without finding a way with which I could contribute in order to mitigate the problem.

Thus, my early experience in low flow roads in conjunction with the proposed project about smart cities led me to this direction. The current project is inspired as a way to bridge the gap between drivers and real data concern with road's conditions.

Incidents in the roads are happened randomly and in any time without drivers to know the real conditions in the streets.

Thereby, we are calling to overcome two problems. Firstly, the information is coming from users and in many cases is inaccurate or misleading. Thus, mechanisms which would be able to evaluate this information are needed. Some existed mechanisms in conjunction with others will be used to minimize the probability for inaccurate information. Secondly, it is important the information to be published quick and immediate in order the drivers to be aware for the situation in roads and to bypass the roads with low flow.

1.2. Research goal

The research goal of this dissertation is to design and develop a mobile application that in a real-time will depict in a map the points with high congestion. The users will be able to report an incident by clicking in the map and to vote other reports. Moreover, incentive methods are needed in order to empower the users to participate. The application is based on users and without their contribution is useless. An extended research will be carried out in motivation methods which should be used in order to be achieved the best results. Exploring novel ideas, approaches and algorithms and using them to find ways to produce trustworthy data is another goal for the research. In particular, we intent to

- Create a mobile application which will be functional and useful to users
- Find alternative ways in order to be published trustworthy and on time reports
- Figure out appropriate incentive methods which will be enforce citizens to participate in maximum

1.3 Document Structure

Chapter 2 explores the current state-of-the-art in types of crowdsourcing, including the reasons we use them and the criticism about crowdsourcing. Moreover, in the same chapter we discuss about participatory sensing which it is the main idea behind this project. The incentive methods that used in relative applications described and finally, the most common ways that used nowadays to monitor traffic analyzed and discussed. Chapter 3 describes the design of the system, explaining all the algorithms needed in order to achieve our initials goals. It is referred the incentive methods that used to motivate individuals to participate. Also, we explain through which ways we try to achieve immediate reports and how some given information can be useful in order the user to evaluate correctly the trustworthiness of the reports.

Chapter 4 discusses the technical and functional architecture of the system by giving graphs and explaining all the components. Then, it analyzed the results by providing screen shots from application and by describing all the methods used to make the communication between server and client. Chapter 5 evaluates the project and retrieves useful results about the functionality and usability of the application. Furthermore, we test if the equations can work properly in order to provide trustworthy reports and in which degree the given information are useful to the users. In chapter 6 it refers the future work that should be done in order to improve our project.

Chapter 2

State-of-the-Art

"A million heads is better than once". This is a new aspect that the last decades more and more people/companies rely on it. A book "*The Wisdom of Crowds*" which is written by James Surowiecki supports this aspect through many case studies and anecdotes. Without the extraordinary blossom of novel technologies, this new aspect could not be implemented. In particular, the spread of Web has contributed positive to the immediate and low-cost communication amongst users. Moreover, devices such as smartphones and sensors, conduct in order to extent the above aspect like sensing real information from the environment.

The remainder of this chapter discusses background research and the state of the art as far as crowdsourcing and participatory sensing are concerned. In the beginning, it will investigate the types and the social impact of crowdsourcing. Therefore, the new arising phenomenon, "participatory sensing", will be discussed, with its advantages and disadvantages and the privacy issues which are generated via this phenomenon. Furthermore, this discussion is followed by the methods which motivate the crowd to participate and the existing mechanisms. Finally, an overview of the existing alternative ways which are facing the traffic jam problem in big cities.

2.1 Crowdsourcing

Before, finally, to be decided a name to this idea, scientist from different fields and countries referred to this effort with many names such as user-generated content,

peer production, collaborative systems, community systems, social systems, social search, social media, collective intelligence, wikinomics, smart mobs, mass collaboration and human computation [12]. Crowdsourcing consists of two different words from crowd and outsourcing. The term was coined by Jeff Howe back in 2006 and the definition that gave to it was:

"Crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial perquisite is the use of the open call format and the large network of potential laborers." [23]

2.1.1 Types of Crowdsourcing

Crowdsourcing can be divided in many different subclasses according to the way we harness it. Confusion exists around the name of these subclasses because people use different definitions and names for the same subclass. Crowdsourcing can be divided in the following types: crowdcasting, crowdcreation, crowdvoting, crowdfunding, microwork, crowdcollaboration, crowdcontent, crowdopinion.[28] In this research they will be referred only the most common types of crowdsourcing.

Crowdvoting

The main purpose of crowdvoting is the public judgment and it happens when a web site collects opinions from the crowd on a certain topic. It is the most popular way of crowdsourcing which concentrates the highest levels of participation. Crowd voting is based on the 1:10:89 Rule which states that out of 100 people:

- 1% will create something valuable
- 10% will vote and rate submission
- 89% will consume creation

Crowdvoting is not a new phenomenon. In 1714, the British government asked people to find a solution to a problem called “The longitude problem” [25]. Nowadays, there are plenty examples that are based on this idea from reality shows to Winter Olympics event [24].

Crowdfunding

Crowdfunding is the process of funding an idea by individuals or companies conducting an amount of money in order to reach a certain monetary goal. Producers decide to fund in other industries without visible profits or customers pre-pay for a product despite knowing it will be freely available [26] . The inputs from the individuals in the crowd trigger the process and specify the value of the product or service. There are more than 450 crowdfunding platforms[27]. The most popular platforms are KickStarter, Indiegogo, Fundable. As a result, internet-based crowdfunting platforms connect thoushands of creators and funders together, empowering people to realize the creative work. Moreover, the platforms are contributing in order to allow more people to participate in the creative than before, potentially leading to increased economic and social prosperity.

Microwork

Microwork is a system in which a task is divided into subtasks and after that published in a common system in which the user can choose and accomplish them for some reward monetary or non-monetary (e.g. reputation) [15]. The main idea behind microwork is to assign tasks to stakeholders that would be difficult or even impossible to be solved by computers. Some represented examples from the above tasks will be find relevant information, recognize object in images or video, natural language processing. All the above tasks require human intelligence and because artificial intelligence is not developed enough in this field it is better than such tasks to be assigned to humans.

The below image depicts all the types of crowdsourcing and the most popular websites that involved in these types.

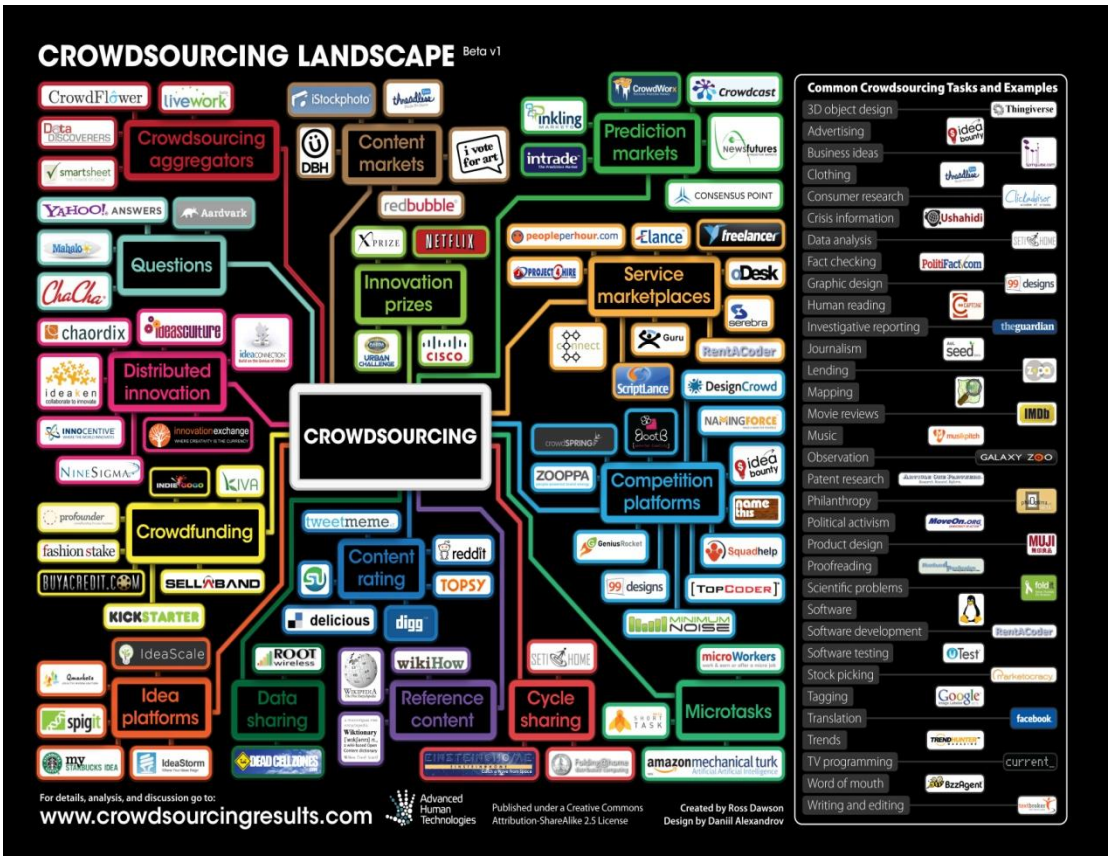

Figure 2.1: Crowdsourcing Landscape

2.1.2 Criticisms of Crowdsourcing

Crowdsourcing is an appealing method to address an issue due to the fact that is a cheap and quick solution. The monetary reward that assigned to the crowd is minor and for this reason two issues arise. Firstly, it is concern about product quality and secondly it is about the ethical concerns of low wages paid to participants.

Data quality

Through the collaboration of a large number of participants the needed time to collect data and to process data are accelerated. Due to the proliferation of the use of the crowd to accomplish small tasks through an open call, many scientific research and other tasks, which are based on crowdsourced information, are doubt [29]. In plenty cases, incorrect results are caused by participants. Since participants are rewarded by tasks and there is no other motivation, participants care only to

accomplish the task as soon as possible rather than well. As a consequence, multiple workers need it to verify the results and to correct the errors. However, completing each task multiple times increase monetary cost and time.

The sample of participants is not random as it is seemed with the first impression. Due to the fact that monetary reward is minor, the crowdworkers mainly are poor users and the most of the times with low education background [30]. Consequently, the results' reliability is doubt and a lot of research should be revised. Furthermore, other results from research are based on data that gathered from all around the world through crowdsourcing platforms. Some platforms are highly biased in terms of the home country of the employers. For example, a USA bank account is needed in order to place a take on MTurk and the money can be transferred in a USA or Indian bank account or can be used in amazon.com shop. Thus, due to the above restrictions, the majority of the workers come from India [30]. The prevalence of such minor monetary rewards is forcing to a homogenization of the Mechanical Turk participant pool. In March of 2008 the percentage of Indian participants was 8% and by November of 2009 increased to 36% of the general population [31].

Ethical Concerns

Apart from reliability of results, ethical concerns rise as far as crowdsourcing concerns. The purpose of this section is not to define what is ethical and what is not- the discussion endures since the time of Socrates. The monetary rewards that stakeholders take for their participation are minor and this is an issue that organizations and governments should think about. The crowdworkers' wages has swung compare to laboratory participants, for the same task. The Turkers often take, for hourly wage, approximately 50% of the US Federal Minimum wage [31]. When the federal minimum hourly wage is 7.5$ is it ethical to pay 2$ per hour online [32]. In 2008, when Facebook started its localization program, criticism and rumors broke for harnessing crowdsourcin techniques to obtain free labor [33].

Additionally, there is no-disclosure agreement or contract between crowdworkers and employees. Consequently, in some common platforms as Amazon Mechanical Turk the requestors, according with the individual result, decide whether the user's

task is acceptable. Thus, in most cases this entails that the participants do not be paid.

Finally, firms/companies assign to crowdworkers to do “fraud click” -repeatedly “click” on the internet- in a specific advertisement or a website in order to increase the revenue of the advertisement or the website respectively [34]. Thus, the results’ reliability again is doubted without knowing whether the information from the crowd is real or fake.

2.2 Participatory Sensing

Nowadays, in mobile phones have emerged new technologies -processing power, embedded sensors, storage capacities and network data rates- which can be combined together contributing to novel paradigm for monitoring the urban land space. Smartphones are able to capture images, find location and transmit data interactively or autonomously. These ubiquitous devices given the right architecture, can act as sensors and location-aware tools. It is not surprisingly that more than 5 billion people globally harness mobile phones. The ubiquity ability coupled with mobile phone technology have paved the way for a new method of gathering information from our environment, known as Participatory Sensing.

The key idea behind this method is to motivate citizens to gather and share sensed information from their urban landscape using their mobile phones. It can range from individuals observation to combination of hundred even thousand people that share data across the entire city.

Usually participatory sensing applications send their information in centralize system (e.g. Server). The sensor data that gathered from mobile phones are reported to the server, commonly using wireless communication. The server analyzes the data and can create graphical tables or maps which are useful information for the end users, as depicts in Fig.2 [4]. The sensor data triggered autonomously or interactively.

Finally, the analyzed data can be accessed by local mobile phones or by larger public through web portals, accordingly to the application's architecture.

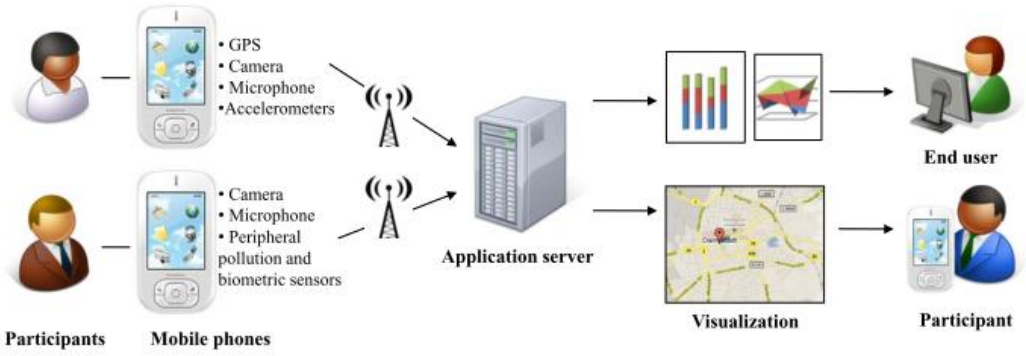

Figure 2.2: Architecture for Participatory Sensing Applications

2.2.1 Analysis of Participatory Sensing

Advantages

Participatory Sensing offers a number of advantages over traditional sensor networks which entails deploying a large number of static wireless sensor devices, particularly in urban areas. First, since participatory sensing leverages existing sensing (mobile phones) and communication (cellular or WiFi) infrastructure, the deployment costs are virtually zero. Second, the inherent mobility of the phone carriers provides unprecedented spatiotemporal coverage and also makes it possible to observe unpredictable events (which may be excluded by static deployments). Third, using mobile phones as sensors intrinsically affords economies of scale. Fourth, the widespread availability of software development tools for mobile phone platforms and established distribution channels in the form of App stores makes application development and deployment relatively easy. Finally, by including people in the sensing loop, it is now possible to design applications that can dramatically improve the day-to-day lives of individuals and communities.

The main processes in participatory sensing

Despite the way and how individuals participate in participatory sensing, the main process is the same across the approaches. The basic steps that each sensing process has are the following: coordination, capture, transfer, storage, access, analysis, feedback and visualization.

Coordination referred the recruiting and communicating process with participants in order to be provided guidance and details about the sensing effort. The coordination can be achieved through existing social networks which can be accessed via devices like computers, mobiles or through face-to-face communication.

Capture is the process of gathering data on mobile phones or others devices. Except from standard capabilities that mobile phone has, others application can be download to support users to collect useful data.

Transfer of data is achieved utilizing mobile phones and wireless networks. According to the scope of project, either the organizers or the participants will bear the cost of data transfer.

Storage is carried out on distributed servers across the Internet. The servers will be privately owned servers which can be used for privately accessed storage services or share oriented services.

Access is usual depend from the policies which have defined from organizers and participants. It is very important to keep the data secured and private from malware users. Users should entrust the system and share their personal data through the application.

Analysis includes the data-processing methods such as aggregation of contributed data for display to the participant, classification of user's activity, image processing that smooth blurry images.

Feedback is usual required in some projects in order to trigger manual or automatic events. For example, according to the user's location (national park) can be triggered a message to notify the user to take a picture or to record a sound.

Visualization goes together with analysis and is the final step where the data are displayed to the participants or project organizers. The project's effectiveness depends on how well the depicted results are understood by the users. Methods such as mapping, graphing and animation contribute to be achieved better visualization.

2.2.2 Privacy

When we exchange all of this information through the internet, privacy issues arise. Because exchanging data provoke all of the information as far as our location, habits and personal data concern. But before we go on, we should define what privacy is in participatory sensing because sometimes it is vague and new enquires are created.

> *"Privacy in participatory sensing is the guarantee that participants maintain control over the release of their sensitive information. This includes the protection of information that can be inferred from both the sensor readings themselves as well as from the interaction of the users with the participatory sensing system.* [4]*"*

In many times the collected data can be reused without the affirmation of the sender and acquaintances, friends or authorities may exploit this information. At the extreme, cellular phones can be turned into the most widespread surveillance mechanisms in history. But the challenging issue is how to maintain privacy without affecting the quality of data. Many researchers have tried to address this problem but there had consequences in the quality of their data [36] and others assured data privacy but under controlled circumstances [37]. When mobile phone is used in sensing data can be turn into tool for self and community research or surveillance. How this tool will be used is depended on who collects the data, how it is handled, and what privacy protection users are given. Privacy decisions consist by many privacy components. These components mainly including time (how long will the data be retained to the system?), identity (who is interested in the data?) and granularity (how much information does the exchanging data reveal about me?).

Nowadays, there are two main types of attacks which create privacy issues in participatory sensing. First, a node which has the ability of decrypting data may compromise the transmitted data to unauthorized users. Secondly, a third party may interleave in the communication between two nodes and eavesdrop the wireless transmitted data[38]. Additionally, the ubiquitous computing environments are more vulnerable compare to wired networks. The malicious users can easily acquire the location information without user's permission and the most of the times the user never knows that his personal data leaked. The attacker is able to collect and analyze the victim's location information within a certain period of time and to record the user's movements.

2.3 Incentive methods

Crowdsourcing harvests the intelligent and the wisdom of a crowd or community in order to accomplish a specific task or to solve a problem. The challenging in crowdsourcing is to generate a productive crowd and community that it will be interested in accomplishing the assigned task. So, the problem for anyone seeking to implement crowdsourcing is how to attract the crowd to participate and how to motivate them to go on until the end?

In the last decades, many researchers and scientist have different theories about the reasons that enforce crowd to participate and what gratified individuals during participation. Also, the ways in which users are gratified nowadays, such as Internet and generally new technologies, are completed different than existed decades ago as newspapers and television. Today, stakeholders do not merely seek satisfaction from content; nowadays are the most of the times producers and consumers, what a futurist Toffler (1980) coined a "procumer", of media content. This leads us to the conclusion that the findings from old researchers still have some relevance with the present era. Most important from their findings were that audience was not a passive receptacle but in contrast wanted to be fundamentally interactive. The internet, combined with Web 2.0 and other novel technologies, toward massive

user-generated online content, is the mean for distributed, large-scale, pleasurable production.

Motivation is chiefly categorized into two parts- intrinsic and extrinsic. Intrinsic motivations are referred the incentives that driven by an interest in the task itself and don't rely on external pressure. The motivation is considered the process to release, control, and maintain physical and mental activities. Incentive methods determine accordingly the quality and quantity of contributions.

The most significant extrinsic motivational factors that boost individuals to participate are reputation, reward, status, fame, fun, community identification. Fun and pleasure are considered the two prominent motivational factors in online platforms. Participation in online platforms initially commenced from the open source software that highly skilled programmers contributed free their skills and their knowledge [9]. Below are the main reasons which attract the individuals to participate in crowdsourcing tasks.

Rewards

Reward is referred as something given to someone in exchange for his/her good work or behavior. Rewards, usually, are given in two forms, monetary or non-monetary. Rewarding money is the best motivation in order to attract people. The disadvantages are that it is costly and that the users lose their interest quickly. For the non-monetary rewards category, the "points" reward is the most common form. The user is rewarded with a number of "points" according to his contribution. The individuals are able to exchange their points with other types of tangible reward, such as goods, holidays, tickets, products etc. Moreover, the reward except from tangible can be intangible reward, such as more access to the system [8].

Leaderboards or Ranking

This technique is used to attract participants. The idea is to let know each member where he is standing among the others contributors and to reward only the top ranking users with monetary or non-monetary reward. The key point to this method is to let the individual know how he can get to the top of the ranking, for example by

contributing more ideas. This tactic triggers the user's desire to compete with other members. This is the reason why the leaderboards are usually open for public view. The drawback is that it cannot attract people that are less competitive or don't have the desire to compete in public.

Reputation

In order to work efficient this technique, it should exist a mechanism to help participant to express to others his current reputation in the system. It is quite different with the ranking system. The ranking system only publishes the top contributors, while this strategy uses name of position or status. The more an individual contribute the more reputation he will have which also implies accessibility to more parts of the system for this user. The user who has more privileges to the system feels superior against the other uses motivating him to go on and simultaneously encourages others participants to work harder.

Entertainment

More recently, in the field of online marketing, has begun to be adopted ideas from game design, to incentivize desirable user behavior. This approach is referred with the term of gamification [22], which means to incorporate the game play elements into the non-gaming applications, services and systems, to drive user engagement. The main idea is, to turn into non-game systems to "gamefied" systems, by adding game mechanisms on the top of their main functionalities. In other words, the ultimate goal of gamification is to incentivize a non-game system user to have game-like behavior such as, multitasking under pressure, work overtime without discontented attitude, always keep trying when fails etc.

2.4 Traffic Jam Control Systems

Traffic jam is one of the most significant problems that big cities suffering from. This problem is nothing new, as the most people believe. Even thousands years ago, in

ancient Rome had quite familiar problems. Julius Cesar was so incensed about this problem that he declared a daytime ban on carts and chariots. In our era obviously this phenomenon is noxious with many consequences to the environment and to the citizens. Many sociologist, analysts, researchers have tried to address it but the roads in big cities signify the problem that still exists and is becoming bigger and bigger. To solve any misunderstanding in this research we don't have the ambitious to solve it but to take a bit out of this problem.

One of the most common technique that many researchers are trying to approach is the image processing where cameras monitor the traffic by capturing videos [39]. The system captures frames at particular time intervals. The consecutive frames are analyzed and according to some parameters determine whether there is a traffic jam. Many monitoring systems have difficulties with shadows and various lighting conditions extracting false results. Moreover, the monitoring system is expensive solution due to the fact that plenty cameras are needed in order to monitor traffic jam in all streets in a big city.

Other probe systems calculate congestion and traffic flow through speed reports, which are send them from a set of GPS-equipped vehicles. They can automatically report, position, travel time, traffic incidents to a telematics service provider. On one hand it has low cost of implementation, but on the other hand it raises some privacy issues such as user's location. Furthermore, the typical GPS receivers have accuracy about 10 meters, which makes it quite complex to pin-point a crossing for the purpose of congestion measurement. Novel methods as Virtual Trip Lines (VTLs) [12] are proposed to address the challenges that are created through this technique. VTLs are used as geographical markers which stored in the client, where trigger a position and speed update whenever a probe vehicle passes.

The usage of sensors like RFID tags and readers for monitoring the traffic is an evaluating way that more and more researchers and analysts harvest. The need for RFID readers and RFID tags make it more complicated because RFID tags should be put to vehicles and RFID readers should be put to the roads that suffering from

traffic jam [40]. Also, the necessity of tags and readers to be tuned into the same frequency makes more difficult the implementation of this technique.

Other technique instead of using sensors to measure the road flow, is to use individuals. This technique called participatory sensing and the users collect data from their environment harnessing mobile devices and web services to share this information. Applications like WAZE[41] are used worldwide nowadays collecting data from the users and illustrating back to them information about the roads. Participatory sensing like all the previous approaches has drawbacks. Privacy issues, trustworthy of sharing data are some of them that many researchers are trying to overcome. Furthermore, this technique premises the installation of a specific application in their mobile devices.

In participatory sensing applications a report from a user is considered as reliable when few users share the same information and confirm the validity. But in order to categorized a report as trustworthy and be published to the rest of the users will take a significant amount of time. In this assignment we will try to find ways to reduce the time it takes to be published a report and also to improve the quality of data.

2.5 Summary

In this state of the art chapter, crowdsourcing is one of the main issues. It referred the general idea behind this word and how finally this method took this name. In addition, the main types of crowdsourcing analyzed, which according to the way it is utilized, it takes different name. Crowdvoting is the public judgment and it carries out when a web site asks people's opinion for a certain topic in order to derive connotations for this topic. Crowdfunding is the process of funding an idea by individuals or companies conducting money in order to gather a certain monetary goal. The method which divides a task into subtasks and after that assigns them in a common system in which the users asked to accomplish them, called Microwork.

On the other hand, the above method may be faster and cheaper than others but many doubt about the trustworthy of its results. Additionally, some ethical concerns discussed which rose when crowdsourcing tasks take place.

Also, another important topic that referred in the state of the art was participatory sensing. The key idea to this method is to empower citizens to collect data from their environment and after that to share this information to the urban landscape harnessing their mobile devices. A brief description gave it, concern about how the above method works. Thus, it was a necessity to be described the main processes in participatory sensing. Coordination, capture, transfer, storage, access, analysis, feedback, visualization are the main steps that are the same in participatory sensing despite the way that it is used.

Privacy issues arise during this procedure. When the users exchange data about their environment, simultaneously they provoke personal information such as location and habits. Firstly, this personal information can be used from the receivers without the user's affirmation. Secondly, because wireless communication is used to transmit data, malware users can acquire the sensitive data without to be known from the sender or the receiver.

All the above will not be happened if the users do not exchange data. Thus, incentives methods are needed to enforce people to participate. Incentive methods divided in two categories, intrinsic and extrinsic. Intrinsic methods are the incentives that driven by desire or interest in the task itself and originate within the individual. Extrinsic methods called the external factors that pressure the individual to participate like reputation, reward, status, fame, fun.

Finally, different approaches that detect traffic jam in the streets discussed in this chapter. Firstly, cameras which monitor the traffic flow and analyze the video - frames and accordingly derive results concern with the traffic in the road. Secondly, GPS-equipped vehicles automatically report position and travel time and according to the reports are derived connotations for the traffic. Thirdly, sensors in the streets monitor the traffic and evaluate the traffic. In the last approach the citizens reports information about the streets instead of sensors and react like sensors.

Chapter 3

Design

In the previous chapter, we described the current state-of-the-art including crowdsourcing, participatory sensing, incentive methods and existed methods to monitor traffic in the streets. This chapter begins with a brief description of our approach and the motivations behind our choice, and then continues with an explanation of the main components before finishing with a brief summary and a discussion of the merits of the design.

3.1. General Idea

The traffic congestion is the one of the most significant issues that large cities suffering from. The main goal of this project is to help drivers/citizens to avoid roads that are blocked for any reason such as incident, accident, strike or is characterized by slower speed or longer trip times or increased vehicular queuing. The passengers/drivers are able to share anytime information about the traffic situation for any street in the whole city. The more users upload information the more accurate will be the information as far as the traffic situation concern. Moreover, it is very important, the information to be immediate and up-to-dated. According to reports, the drivers can avoid the traffic congestion and can choose an alternative road for their destination.

A simple scenario is when a passenger comes across with a car accident, which implies traffic congestion and reports immediate the incident through his mobile device. As much as possible citizens share the same information for the incident then

so more confidante the information will be. Then in the map the incident will be depicted as a marker and the users will react accordingly.

The big issue that we are facing in this application is how to empower people to participate and share information through this application. As we discuss in the previous chapter there are plenty incentive methods that can be used to motivate participants. The reward is a very broad method that is used in many applications. At the beginning of each task, the monetary reward is the most effective method where the users have the willingness to participate. But as the time pass by, the stakeholders lose their interest. Moreover, it is very expensive technique and usually cannot be afforded it. Thus, the non-monetary reward is more suitable to this application. The method that will be used in this application is the bonus reward. Each time the users share information will be rewarded with bonus points. Also, the rank method will be used. The users will acquire a representative rank, according to their current contribution. The situation in the streets is changing all the time and it is unpredictable what will happen in the next minute. The users should upload information as soon as possible providing immediate notifications about the streets all the time. Thus, it is desirable to force individuals to share their information from their environment immediate. In order to achieve that the first user who uploaded a report, he will get extra points.

The users will have the ability to report a notification. If the notification they received is misleading, they can report this information as “false”. If the notification matches with the real situation on streets the users can report this notification as “true”. The point of this procedure is to avoid any misleading information that it will put many drivers into trouble. Moreover, if the negative votes, for a notification, exceeds the threshold (a specific number) then the notification will be aborted and the user who posted it will lose points. By this way, it would be reduced the misleading notifications. If a notification is correct, the individuals can vote positively for this notification and support its validity.

Social networks are one of the latest revolutions in networking, allowing users with familiar interests to exchange data/information across the network and stay

connected as long as they want. They are very broad not only for common Internet users, but also for mobile users that have ubiquitous connection. It is obvious that user trust better a notification that it published from a known person. We will harness this factor by providing the username of the user who published the report.

The effective and accurate information are the main priorities that this application will be built on. The above are very important in order to be created a strong relationship between the users. For example, if the information about a road that published in the application is inaccurate, then there is no reason to use such an application. The users should share and view information that will be useful for them and the others.

3.2 Overview of the design

The goal of this project is to find alternative ways to inform the users about the real traffic conditions in the streets. As we describe in the state-of-the-art there are plenty ways to observe and estimate the traffic flow. Sensors, GPS (Global Position System), cameras are some of them that many scientist and researchers harness for the above purpose. In this project we will utilize the power of the crowd. The citizens will take place of sensors and they will report the traffic congestion through their mobiles.

The main component, which everything else in this project correlates with it, is the reports. In this chapter we will not describe how a user is able to report an incident and how the reports are depicted in the application. We will describe the algorithms that are used behind the application and contribute in order to be achieved a proper application that it will have immediate and trustworthy reports. Thus, we will divide the component report into two sub-components that there is close relation between them.

Firstly, we will describe which incentive methods we harness and how do we use them in order to have immediate reports. Moreover, how incentive methods

contribute in order to avoid misleading reports from careless users. Secondly, it will be described the alternative ways which are used in order to have trustworthy reports.

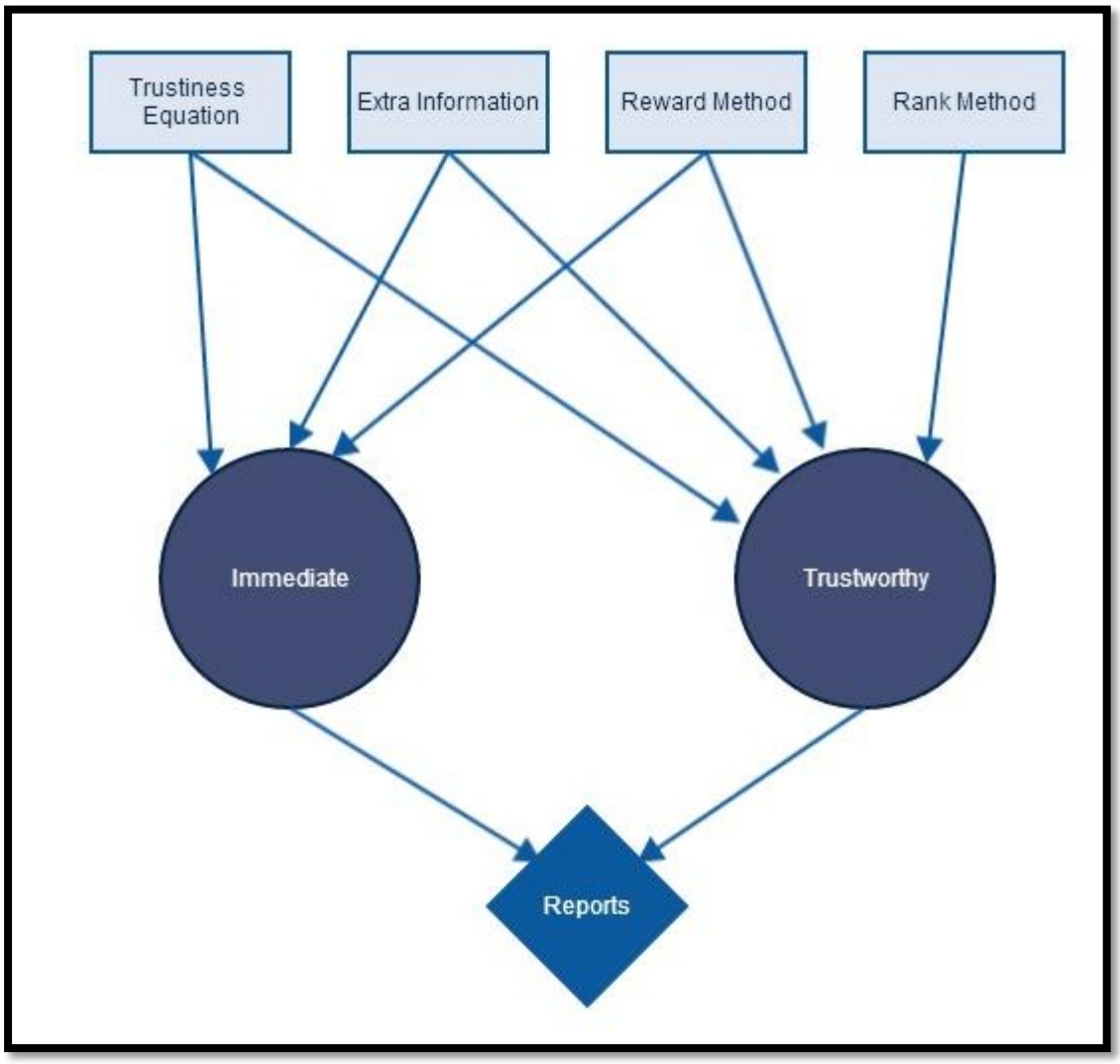

Figure 3.1: Report's Dependencies

Figure 3.1 depicts which methods are used in order to have immediate and simultaneously trustworthy reports. “Trustiness” equation, extra information and reward method contribute for achieving immediate reports. “Trustiness” equation, extra information, reward method and rank method help for having trustworthy reports.

3.3 Incentive Methods

There are plenty of motivation methods that are used nowadays for many different ways. In this project two incentive methods are utilized.

- Reward method, the users are rewarded with points for their contribution
- Ranking method, the users according to their contribution take different rank

Reward Method

Reward method is playing very significant role in our project. We use this method for the following reasons:

- Immediate reports
- Motivate users to participate
- Avoid misleading reports

The main goal of this project is to publish the reports as soon as possible. This depends on how fast the users are. It is important when a road has traffic congestions problems to report it immediately. Thus, the users will be informed quickly and they will choose another road for their direction. Many readers will be wondering what the correlation between points and immediate reports are. Empowering people in such way, is needed an extra motivation. If the users do not benefited more for his immediate and fast action (report an incident), they will not act fast. The first participants who published an incident, they will gain more points according to their position in the queue.

- The first 0,5% from the overall number of users in that city, will gain 50 points
- The second 5% from the overall number of users in that city, from 0,5% to 1%, will gain 25 points
- The next 1% from 1% to 2% it will gain 10 points

If the notification voted from 2% of the overall users in that city, it will be characterized as “trusted”, and the users will not be able to vote it after that and as a consequences to gain more points.

Another reason that we use reward is to avoid misleading reports from the system. Misleading information is main issue that applications which are based in participatory sensing are suffering from. There are different reasons which lead users to share misleading information. First, the users misunderstand the real reason which caused the incident and the consequence of this incident. Second, malware users on purpose share corrupted information to mislead other participants. Third, users who are seeking for points in order to gain better ranks, they are indifferent to notification's integrity and trustiness.

A very common way to avert users from sharing misleading information is by subtracting points from their overall score. The users will not lose the same number of points in each case. The number of losing points depends on the number of users who have shared this notification.

- If N < 0.25% of the overall number of users in the city, then the users will lose 30 points.
- If 0.25 < N < 0.5% of the overall number of users in the city, then the users will lose 15 points.

N is the number of users who have voted a specific report.

Ranking Method

The ranking method is used as an extra motivation that it will empower more the individuals to participate. This method works in conjunction with the reward method because there is close relation between of them. The users acquire ranks according to their current points. The users will be able to acquire the following ranks. The ranks are sorting in ascending way.

- Corporal-Corporal users are all the new users who have from 0 to 200 points
- Sergeant- Sergeant users are the users who have from 201 to 500 points
- Inspector- Inspector users are the users who have from 501 to 1000 points
- Commissioner- Commissioner users are all the users who have more than 1000 points

3.4 Trustworthy reports

One of the main goals of this application is to provide trustworthy information. It is very important the system to publish trusted reports in order to provide useful and real information to the users about the situation in the streets. If the information is not trusted or not up-to-dated the users will abandon this application soon. We use two different methods in order to publish trusted reports.

3.4.1 Trustiness equation

The “trustiness” equation estimates the trustiness percentage of each report. With simple words, for each report there is a percentage which is calculated from the users who have voted it as “trusted” and users who have voted it as “untrusted”. In this equation it plays significant role the rank of each user. It is considered more confident the opinion of users who has high rank than other users who have lower rank. Furthermore, this equation considers as “overall users” the number of users who belong to a specific region. The density of population is different from region to region. Thus, this equation takes into account this diversification and estimates the percentage according to the density of population in each region. When the percentage exceeds the 2% of users in a specific region then the report will be characterized as “trusted” and users will not be able to vote this report anymore.

A notification will be consider as “trusted” according to the following conditions.

- 1st Condition – 2% of corporal users publish the same notification
- 2nd Condition – 1% of Sergeant users publish the same notification
- 3rd Condition – 0.5% of Inspector users publish the same notification
- 4th Condition – 0.25% of Commissioner users publish the notification
- 5th Condition- it is obvious that not only users from the same groups will publish a specific report, but also users from different groups. The above conditions do not include the case that users from diverse groups will vote

the same information and thus a notification will never be characterized as "trusted". The notification will be characterized as "trusted", according to the below equation.

$$\left\{\frac{Uc}{Nc}+\left(\frac{Us}{Ns}\times 2\right)+\left(\frac{Ui}{Ni}\times 4\right)+\left(\frac{Ucom}{Ncom}\times 8\right)\right\}\times 100 \geq 2\%$$

Equation 1

N_c – Overall number of Corporal users
N_s – Overall number of Sergeant users
N_i – Overall number of Inspector users
N_{com} – Overall number of Commissioner users

U_c – Number of Corporal users who have submitted a specific notification
U_s – Number of Sergeant users who have submitted a specific notification
U_i – Number of Corporal users who have submitted a specific notification
U_{com} – Number of Corporal users who have submitted a specific notification

The Uc, Us, Ui and Ucom numbers calculated by adding the number of users who have voted this report as "trusted" minus the users who have voted this report as "untrusted".

3.5 Extra information for trustworthy reports

"Immediate reports" is main goal of this project. If the users have to wait until a report characterized as "trusted" then we will not have achieved our initial goal. In order to achieve this goal and also to have trustworthy data we provide two parameters to users for each report.

Trustiness percentage

An information that is confirmed from many individuals is considered more confident and users can trust it compare with an information that only one user support it. Thus, this project exploits the theorem that many individuals are better than one. In the application we will depict the "trustiness" percentage for each

report until the report to be characterized as “trusted” or to be aborted. By providing this information the users will be able to decide if the report is trusted or not and can react accordingly. If a user does not trust a report because its percentage is low, he should wait until the percentage gets higher.

Username

In conjunction with the percentage it will be provided the name of the user who published this report. Humans trust better a known person than an unknown. By providing this information the users can trust a report if they know the person who published this report. Even when the “trustiness percentage” for a specific report is low, the users can trust this report if the user who uploaded this information is known to them. Thereby, when a report uploaded and the users trust this information we have achieve to publish immediate reports, because the users do not have to wait until the report to be characterized as “trusted”.

3.6 Summary

In this chapter we referred the main methods that we will use in our project in order to have immediate and trustworthy reports. The reward method used to empower users to participate and in parallel to empower them to report immediately. Rank method works as extra motivation. “Trustiness” equation takes into account the rank of the user and population density in this region. The equation indicates if a report is trusted or not. Moreover, if a report is not “trusted” yet, we provide the current percentage and the username of the user who published this report. The users according to these data will be able to evaluate the report’s trustworthiness.

Chapter 4

Implementation/Results

In the previous chapter described the general design of our project and methods which used in order to develop our application. It referred the reward and ranking methods which used as incentive methods and how these methods contribute to the overall project in order to achieve trustworthy and immediate reports. Then, they discussed the “trustiness percentage” and the “extra information” that are utilized in order to publish reports as soon as possible and to provide extra information that the users can take into account to evaluate the trustiness of the reports. This chapter will begin with a brief introduction to our implementation. This will be followed by an explanation about the technical architecture, the functional architecture and the structure of the database. Finally, it will be explained the application, its main methods and the background communication that happened between the server and the application.

4.1 Implementation Description

Our implementation is divided in two main components that cooperate together all the time. The first component is the server which connects directly with the database. It is responsible to provide the information that the clients are requested such as profile information and reports information. The second component is the mobile application that the users can make request to the server in order to commit

some tasks as view reports, vote reports, view my profile. The whole project is written in JAVA language. With the help of tool Eclipse Java EE IDE version Juno we develop the application server and with the tool Eclipse version Android Developer Tool we develop the android application. For our database we use MySQL version 5.5.

4.1.1 Technical Architecture

The system is separated in two parts: the mobile application and the application server.

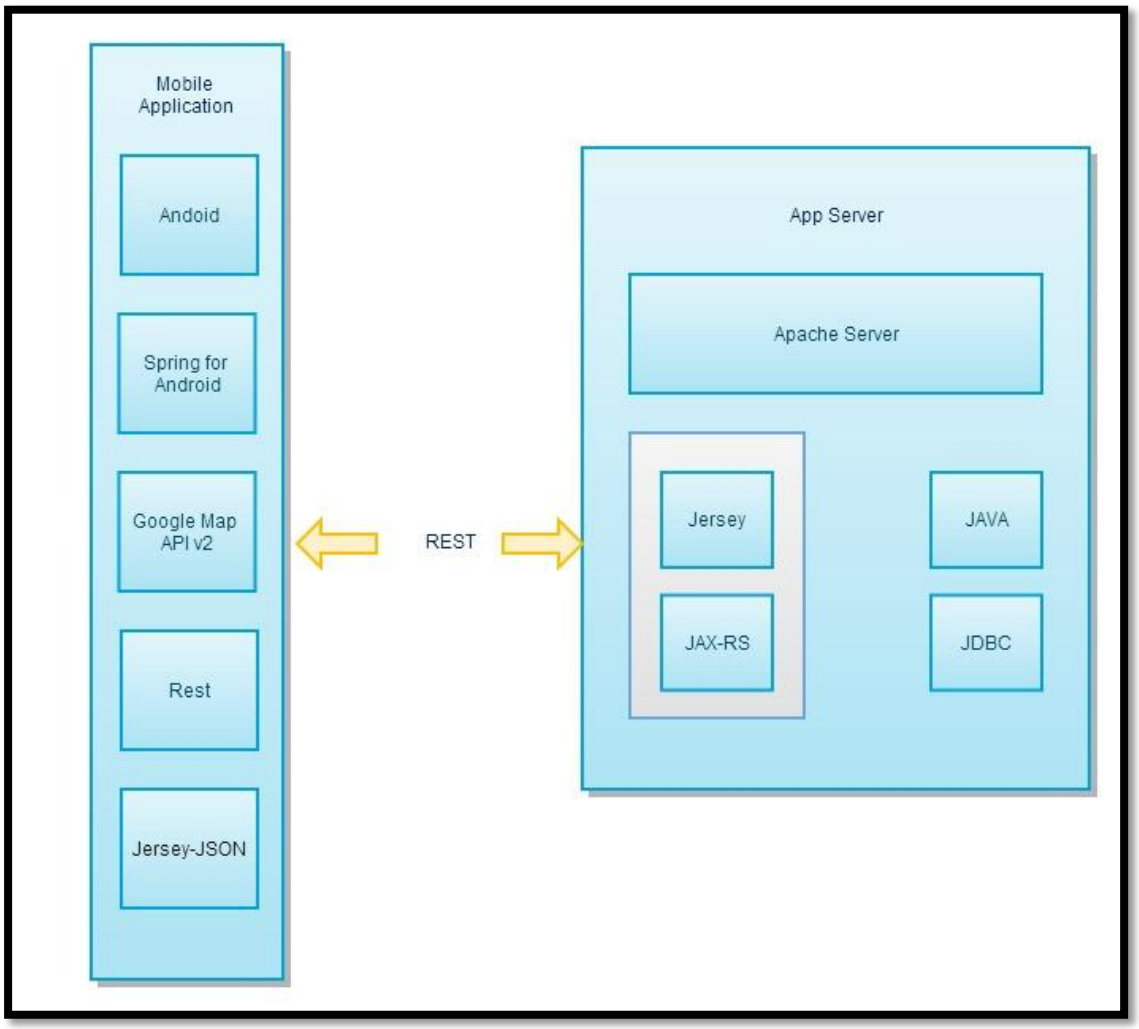

Figure 4.1: Technical Architecture of the System

Mobile Application

- The application is written in Android due to the fact that is an open-source that the users can develop their own applications free. Moreover, over of million people are carrying android devices worldwide. As of May 2013, totally 900 million android devices have been activated and around 48 billion applications has been installed from the android platform, Google play store [42]. Finally, android is an operation system that is written primarily in a customized version of Java programming language.
- The mobile client is based on Spring's Rest Template. Spring for android helps in easy development of Android applications.
- The Google maps android API v2 is used to add maps based on Google maps data to our application. Google maps android allows offering interactive, feature-rich maps to users of our android application. The API v2 handless access to Google Maps servers, data downloading, map display and response to map gestures. Moreover, we can use API calls to add markers and overlays to a basic map and to change the user's view in a specific area. Also, it provides additional information for map location, allowing to the users to interact with the map. Finally, it allows us to add graphs to the map like icons anchored and to put them in a specific position in the map (Markers). These markers will be utilized for depicting the traffic incidents in the map.
- The data transfer is performed using JSON (JavaScript Object Notation). This format is a text-based standard designed human-readable data interchange. JSON usually used for serializing and transmitting structure data over a network connection. Generally, it is used to transmit data between a web application and a server instead of an XML format and this is the reason we use JSON.

Application Server

- The application server works as a servlet on Apache Tomcat Server. Tomcat is useful because it works as a webcontainer which allows to run servlet and JavaServer Pages based web applications. Also, Tomcat allows HTTP request which is necessary in the RESTful communication.

- The web services of application server are based on Java API for RESTful Web Services (JAX-RS). The JAX-RS is a Java programming language API which is good to provide support in creating web services according to the Representational State Transfer (REST) architectural pattern. The JAX-RS provide some annotations very useful for our project.
    - @Path which specifies the relative path for a resource method or class.
    - @Get, @Post, @Put, @DELETE which specify the HTTP request type of a resource.
- The connection between the server and the database is based on Java Database Connectivity (JDBC). JDBC is a Java-based data access technology. This technology is an API for Java Programming language that specifies the way a client access a database. Also, it is useful due to the fact that provides methods for querying, inserting and deleting data in the database.

Communication between components

The communication between the android device and the application server is based on REST (Representational State Transfer). Clients make request to the server and then the server process request and return response. Rest utilizes operation like GET, POST, DELETE, PUT and other existing features of the HTTP protocol. There are many reasons that lead us to choose REST for the communication.

- Ease of use
- Requires less bandwidth compare with other methods (SOAP)
- It is much more documented and explained compare to other methods (SOAP)
- It is widely distributed standard [43]

4.1.2 Functional Architecture

The below figure depicts the main functions that used in our system in order to achieve communication between the client and the app server. The functions are categorized according to where they reside, application server or mobile application.

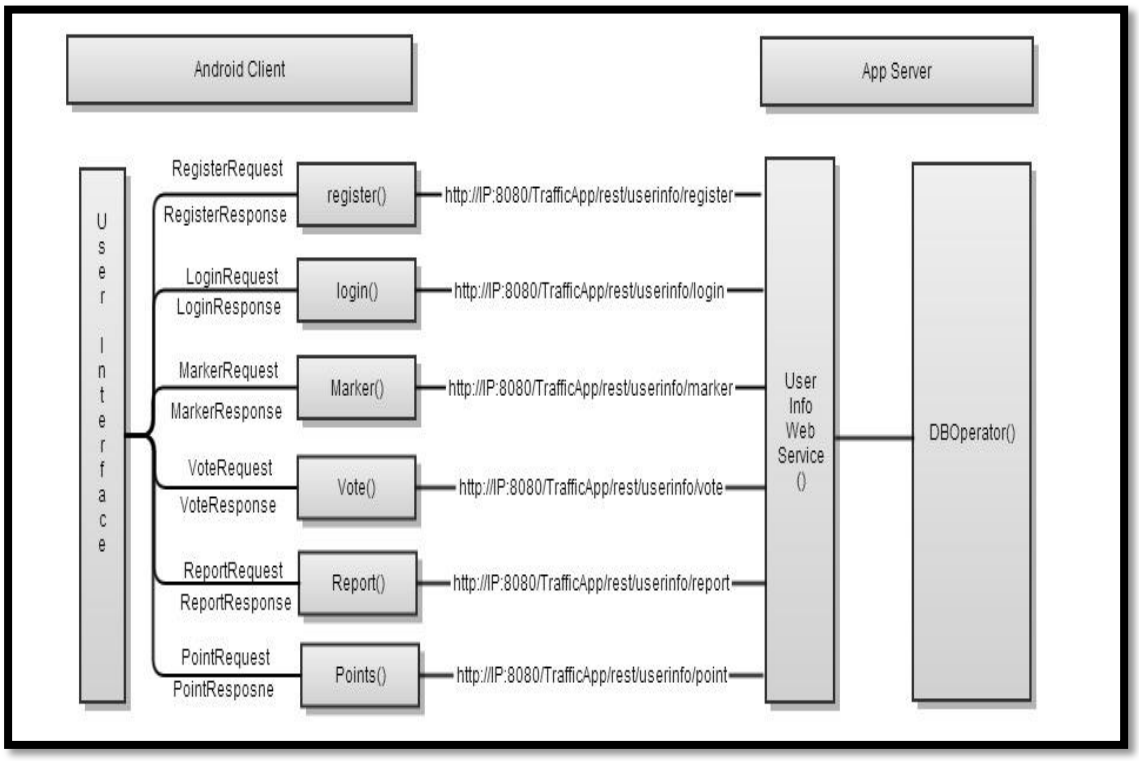

Figure 4.2: Functional Architecture

The above figure illustrates the functions needed to make the communication between the mobile device and the application server. Also, it depicts the HTTP-URL that client uses to request services from the app server.

- **Register**-The user makes a registration request. The user sends simultaneously his username, password and email in order the request to be accepted from the server. The server responds back with a “success” or “fail” message.
- **Login**- The user sends a login request. In order to be accomplished the request. The user should send his valid username and password. The server responds back with a “success” or “fail” message.
- **Marker**- The user sends a request in order to view the current reports. The user does not send any other information along with this request. The server

responds back with the valid reports. For each report sends the longitude, latitude, type of incident, user's percentage and the username who published this report.

- **Vote**- The user sends a vote request. He sends the longitude and latitude of the report which wants to vote and also the value of his vote, "trusted" or "untrusted". The server responds back with a "success" or "fail" message.
- **Report**- The user sends a report request. Along with request, he sends the longitude and latitude of the report's position, the type of incident (accident, road construction etc) and his username. The server responds back to the user by sending a "success" or "fail" message.
- **Points**- The user makes a request and asks his current points and his rank. In order to get back the appropriate information, his username is sent it along with the request. The application server responds with the points and the current rank of this user.

4.1.3 Database Structure

For our database we use MySQL version 5.5, the world's most widely used open-source Relational Database Management System (RDMS). It is useful due to the fact that runs as a server providing multi-user access to a number of databases. MySQL does not support Graphical User Interface (GUI) tools to administer databases or manage data contained within the databases. For this reason it is utilized the MySQL Workbench tool, a free integrated environment which enables users to visually design database structures and graphically administer MySQL databases.

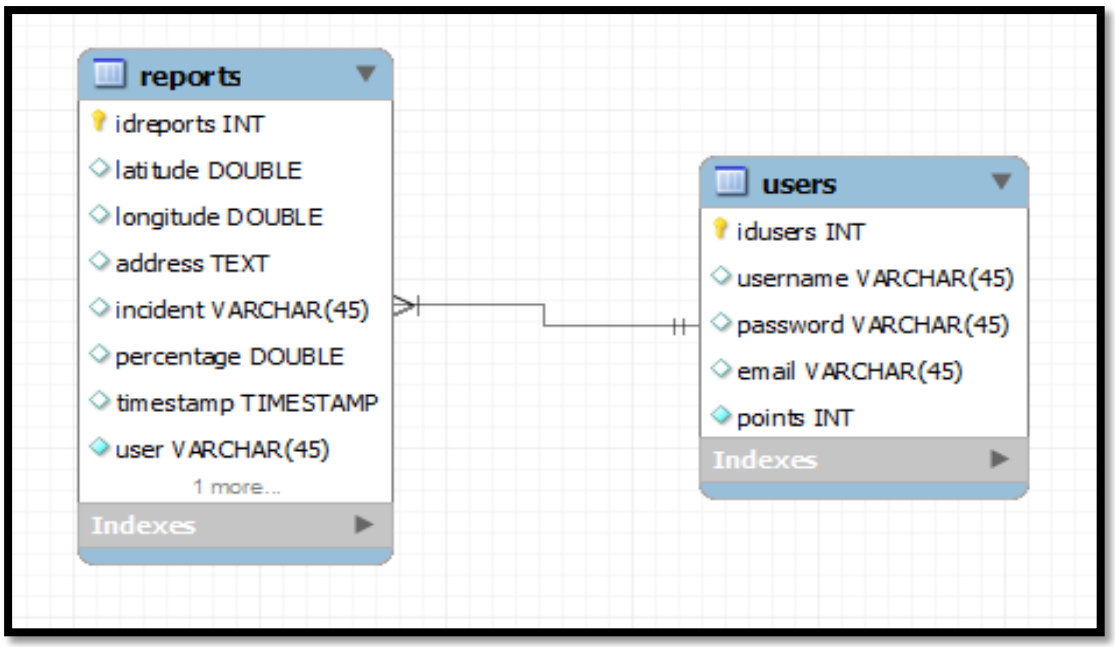

Figure 4.3: Database Structure

The implementation described in the above figure 4.3 uses a very simple schema for storing data in the database, consisting of only two tables- one for storing reports and the other for storing users. The first table, *reports*, stores all the appropriate information needed about reports and contains eight columns.

- *idreports*, the auto-increment primary key;
- *latitude,* the report's latitude where is located in the map;
- *longitude*, the report's longitude where is located in the map;
- *address*, the address the number and the region where the report located;
- *incident*, the type of incident that cause the traffic congestion;
- *percentage*, the "trustiness percentage" for each report;
- *timestamp*, the time and the date of the report;
- *user*, the username of the user who published this report;

The second table, *users*, stores all the appropriate information needed about reports and contains five columns.

- *Idusers*, the auto-increment primary key;
- *username*, the username of the user;

- *password*, the password of the user;
- *email*, the email of the user;
- *points*, the current points of the user;

4.2 Results

In this subchapter it will be analyzed the main methods used in this chapter and will be discussed come up results.

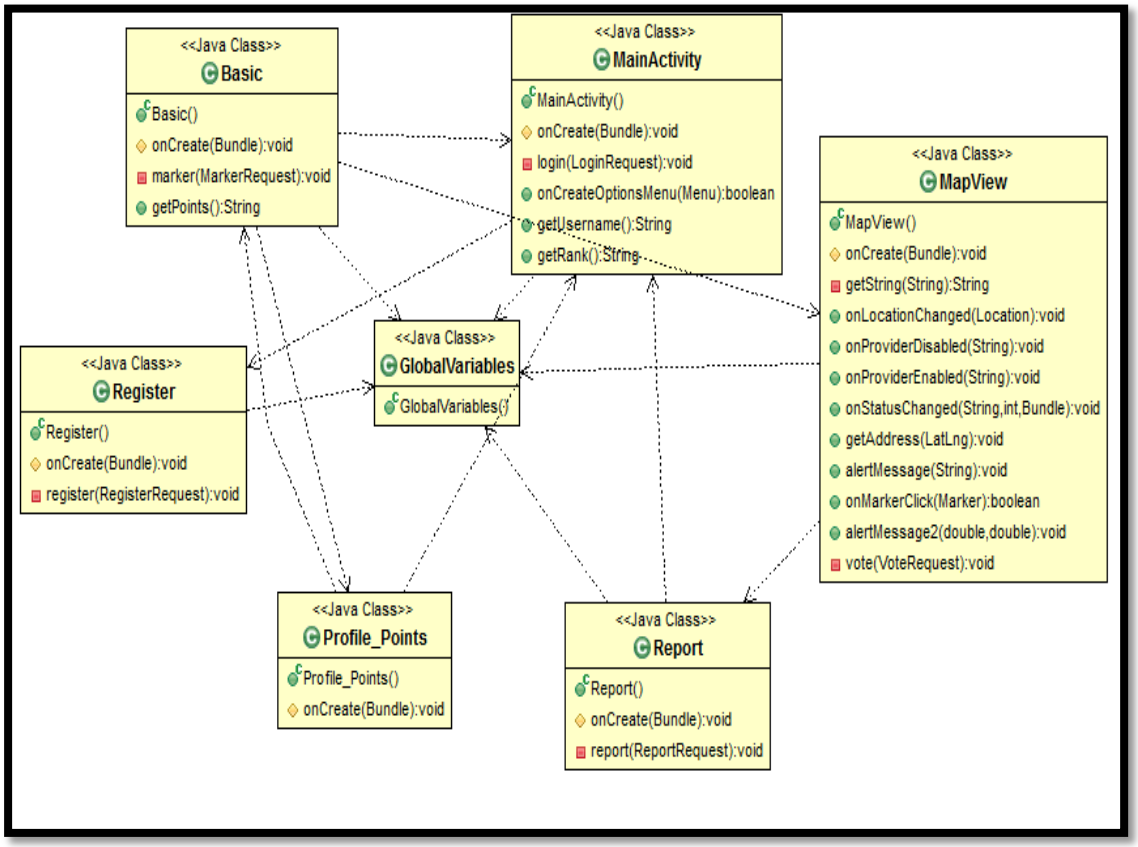

Figure 4.4: Java classes in android device

The above figure depicts the main classes that located in the android device and the dependencies that exist between them. The arrows show which classes depend on others. It will be explained the above classes in conjunction with the classes located in the server side. Almost all the classes in android device request information from the server and communicate together with the server to accomplish the tasks.

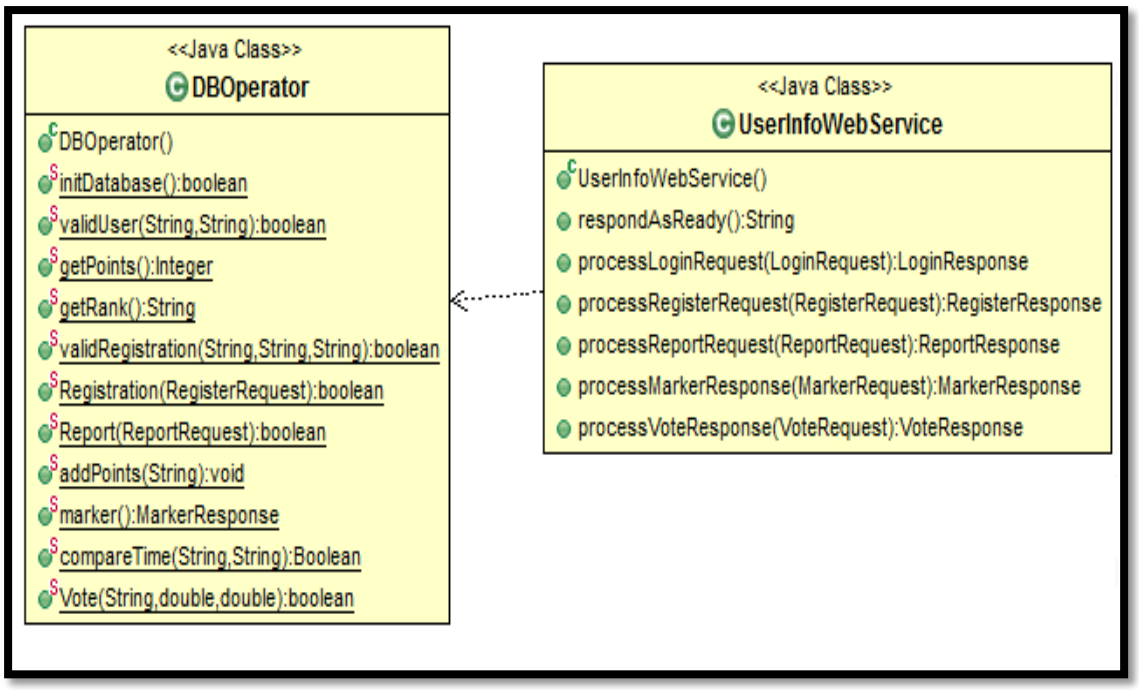

Figure 4.5: Java classes in application server

The figure 4.5 illustrates the classes and the methods which located in the server side and the dependencies between the classes.

MainActivity

The MainActivity is the first activity that appears in the mobile application, figure 4.6. It is a login screen and user should type his username and password to login in the application. If the user types less than four letters in the field or in the password field, the below message appears.

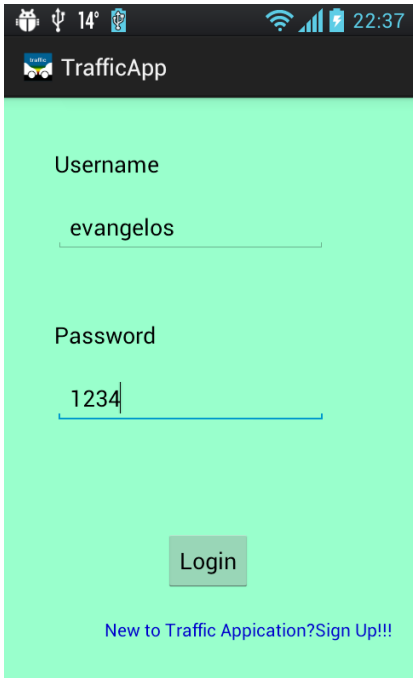

Figure 4.6: Login Screen

- "All fields should have more than 4 chars"

If the username does not match with the password, the below message appears.

- "Login fail"

When new users try to login, first they should make

registration by clicking the link “New to traffic application? Sign Up!!”.

```
ResultSet result= st.executeQuery("SELECT username,password,points FROM
users;");

while(result.next()){
                        if((username.equals(database(“username”)))
            &&(password.equals(database("password"))) )
                        {

                    return true;
}

                    return false;
```

Login validation code

The above code runs in the application server on *DPOperator()* class and in the *validUser()* method. When the user makes a request login, the server examines if the username and the password matches with the stored data in “users” table. If it matches, the server responds with “true” else with “false” message.

Registration

The registration screen, figure 4.7, is useful in the case a new user wants to create an account in order to use the application. The user should type username, password and email to make a registration request. Like in the login screen the user should type a username and password that is more than four characters else the below message will be appeared.

- “All fields should have more than 4 chars”

In the email edit field it should be typed a real email with “@”, “.” characters in the email address else the below message will be appeared.

- “Please give your real email”

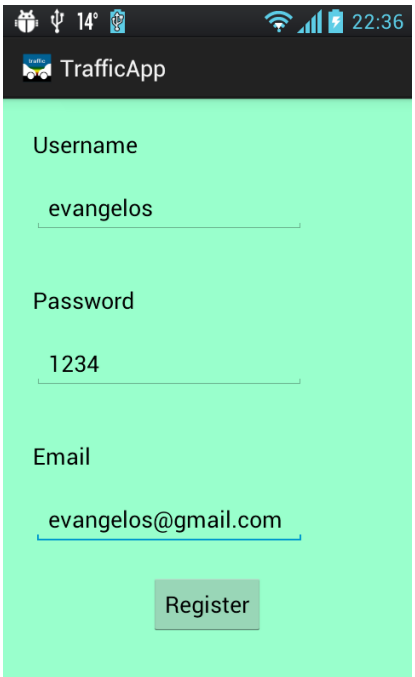

Figure 4.7: Registration Screen

If all the fields fulfill the above prerequisite requirements then a request send to the server with the username, password and email of the user.

```
rs = st.executeQuery("SELECT username,email FROM users");

while(rs.next()){

	//finds if the username and password matche
	if((username.equals(database("username")))
||(email.equals(database("email"))) )
	{
		return false;

	}else
		{
//insert the data in the database
String sql="insert users (username,password,email) values
('"+request.getUsername()+
	"','"+request.getPassword()+"','"+request.getEmail()+"')";


	Statement st= conn.createStatement();
	st.execute(sql);

		return true;
```

Valid registration code

Then, the server examines, in the *DBOperator()* class and specific in the *Registration()* method, if there is another user in the database who have the same username or email. In the case that do not exist same username or email the registration completed and the server sends a “true” message to the application else a “fail” message is send to the mobile application.

Figure 4.8: Main Screen

Basic

The basic screen, figure 4.8, is the main screen that appears when the user login successfully. The user is able by clicking in the main button to view the map with the traffic reports or to view his current

points and rank by clicking the top-left button. In the background of this activity the application requests from the server all the traffic reports. When the user clicks in "View Traffic Map" button the reports will be appeared faster because it will already have this information.

MapView

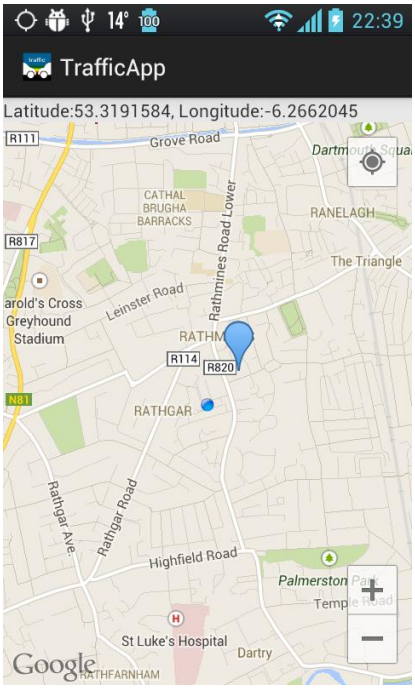

Figure 4.9: MapView Screen

The "MapView" activity depicts the "google map" with the current reports in the streets. The blue bullet in the center of map shows our location in the map.

Current location

To see your current location on the map, click the button with circle and the dot in the middle, on the top-right corner in the screen. By pressing this button in the center of screen will be your location and around of it the available reports, figure 4.9.

Zoom in out Controls

On the bottom-right corner of the screen there is an

icon which is used to zoom in or out the map. By clicking the plus (+) symbol zooms in the map and by clicking in the minus (-) symbol zooms out the map.

Red and Blue Markers

It can be noticed in figure 4.10 that there are red and

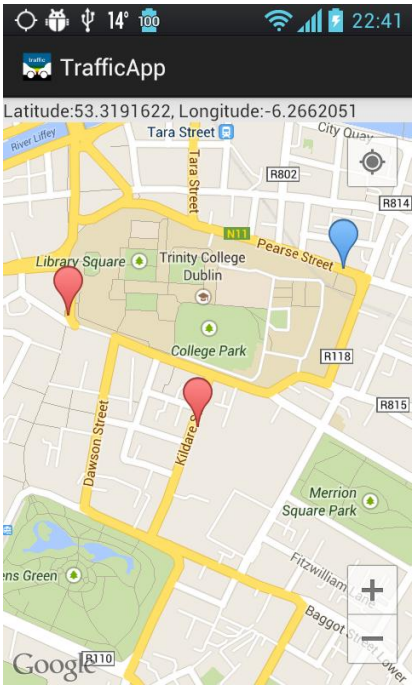

Figure 4.10: Markers screen

blue markers in the map. The red markers symbolize the “untrusted” reports and the blue markers symbolize the “trusted” reports. As we described in previous chapter the “trustiness” equation calculates the percentage of user who have voted a specific report. According to this percentage the markers is painted with blue or red

```
for(int i=0; i<lat1.length; i++)
            {
       Double latitude= arrayLatitude[i];
       Double longitude= arrayLongitude[i];


     LatLng position = new LatLng(latitude, longitude);

//if percentage exceeds 2% is trusted else untrusted
   if(percentage[i]>=2%){
      googleMap.addMarker(new MarkerOptions().position(position)
                          .icon(Blue)//set marker color
                          .title(incident1[i] )//Type of incident
                          .snippet("Trusted")); //extra info
   }else{
       googleMap.addMarker(new MarkerOptions().position(position)
                          .icon(Red)//set marker color
                          .title(incident1[i] )//Type of incident
                          .snippet(num+ "% of users-Untrusted- by
                          "+user[i])); //extra info
            }
           }
```

Trusted or Untrusted report code

color to symbolize if the reports are trusted or not.

The above code runs in the *MapView()* activity and examines the percentage for each report. If it is more than 2%, it sets the color of the marker blue and as information has the “type of incident” and the word “trusted” this means that users can trust this report, figure

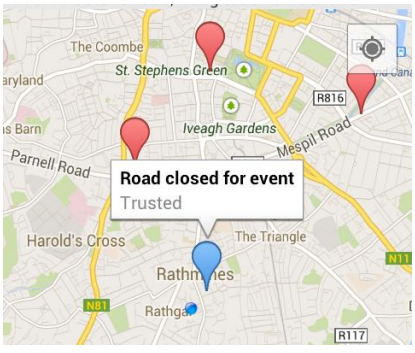

Figure 4.11: Trusted report Screen

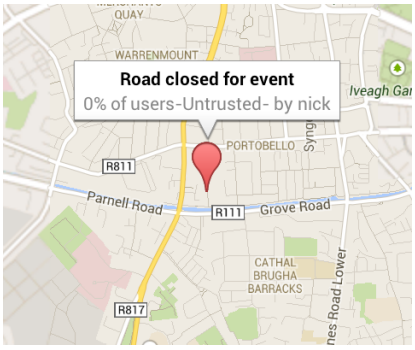

Figure 4.12: Untrusted report Screen

4.11. If it is less than 2%, it sets color of the marker red and as information has the “type of incident”, the word “untrusted”, the “trustiness” percentage and the username of the user who uploaded this report, figure 4.12.

The extra information about each report is appeared by clicking once in the marker.

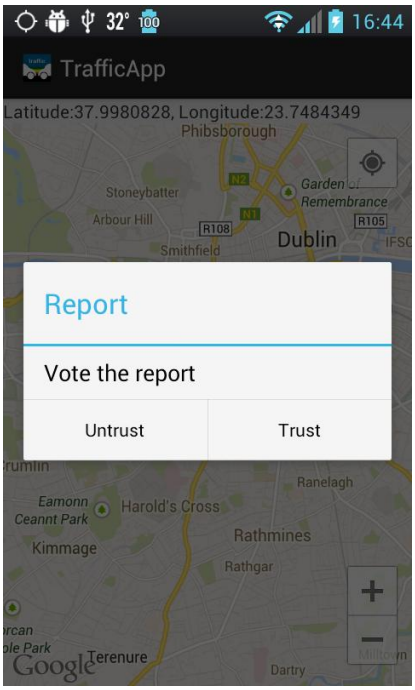

Figure 4.13: Vote Report Screen

Vote Report

The users are able to vote “untrusted” reports by clicking twice over the report. Then, a window

```
DateFormat dateFormat = new SimpleDateFormat("yyyy/MM/dd
HH:mm:ss");
Calendar cal = Calendar.getInstance();

while(re.next()){
       //find the same report in the database by searching the same
       //latitude and latitude that user votes
       if((reportLatitude.equals(latitude))&&
       (reportLongitude.equals(longitude)))
       {

              if (vote.equals("trust")){
                     Integer percentage=currentPercentage + rank;
                     String sqlQuery="UPDATE report SET
percentage='"+percentage+"',
timestamp='" +dateFormat.format (cal.getTime() )
+"'WHERE latitude='"+latitude+"'AND longitude='"+longitude+"'";

       Statement statement= conn.createStatement();
       statement.execute(sqlQuery);
                     return true;

              }else if (vote.equals("untrust")){

                     Integer percentage=currentPercentage - rank;

                     String sqlQuery="UPDATE report SET
percentage= '"+percentage+"',
timestamp='" +dateFormat.format (cal.getTime())+"'
WHERE latitude='"+latitude+"'AND longitude='"+longitude+"'";
       Statement statement= conn.createStatement();
              statement.execute(sqlQuery);
```

appears asking from the user to vote this report, figure 4.13. When the user votes the report, it is send a request to the server. The server changes the “trustiness” percentage for this report according to the vote (trusted, untrusted) and the rank of the user. We said in the previous chapter, users’ opinion that has higher rank is more important than other users. Thus, the “trustiness” equation takes into account user’s rank.

In the above code, when a user votes a report he sends simultaneously the report’s latitude and longitude and his username to the server. Firstly, the above code (it is in the *DBOperator()* class in *Vote()* method) is trying to find a report which has the same latitude and longitude. Then the server changes the percentage of this report by adding or subtracting according to the type of vote and the rank of user. Finally, the server responds back to the application with “true” if it finds a report with the same longitude, latitude else with “false”.

Report an incident

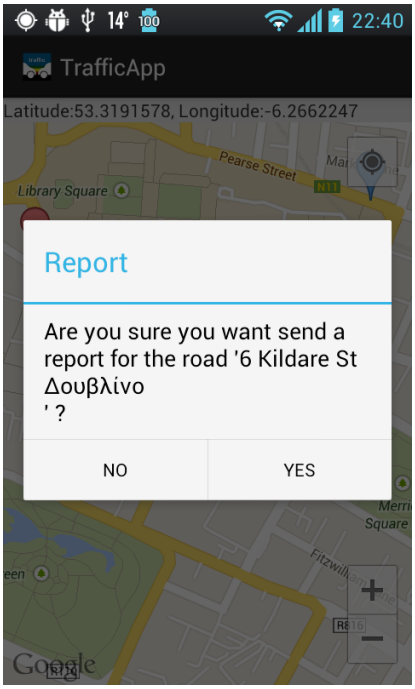

Figure 4.14: Confirmation report Screen

The users are able through the application to report an incident by clicking in the map, in the point where the incident is located. Then, a window appears and asks the user if he wants to report an incident in this point, figure 4.14. If

Figure 4.15: Confirmation Report Screen

the user presses in “yes” option, then another activity appears with all types of incident that can cause traffic congestion, figure 4.15. The user can select one of the suggested options to report the incident.

The server receives the request with report’s longitude, latitude, type of incident and the username of the user who sent the report. Then, in the “DBOperator” in the method “Report”, the server examines if there is other report with same longitude and latitude and then stores the report in the database. Finally, it rewards the user who uploaded the information.

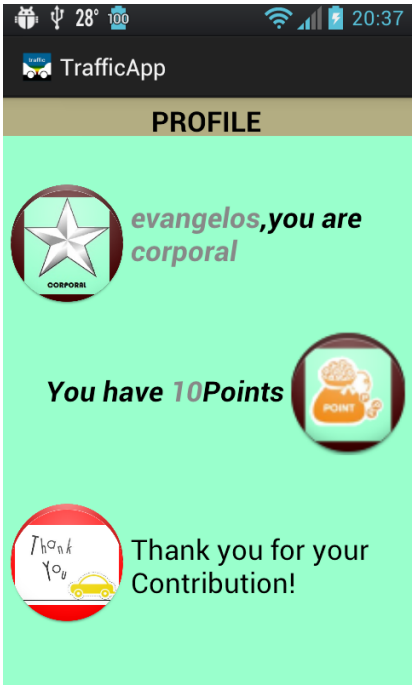

Figure 4.16: Profile Screen

Profile

The users can view their current points and rank by clicking the top-left corner in the basic screen, figure 4.16. The application sends request to the server and asks the points of the current user. In the *DBOperator*() class in the *addPoints*() methods, the server finds from the database the points of this user and responds back with the points. The user receives rank according to his current points. The image changes according to user’s rank. Below there are all the ranks and the related images, figure 4.17.

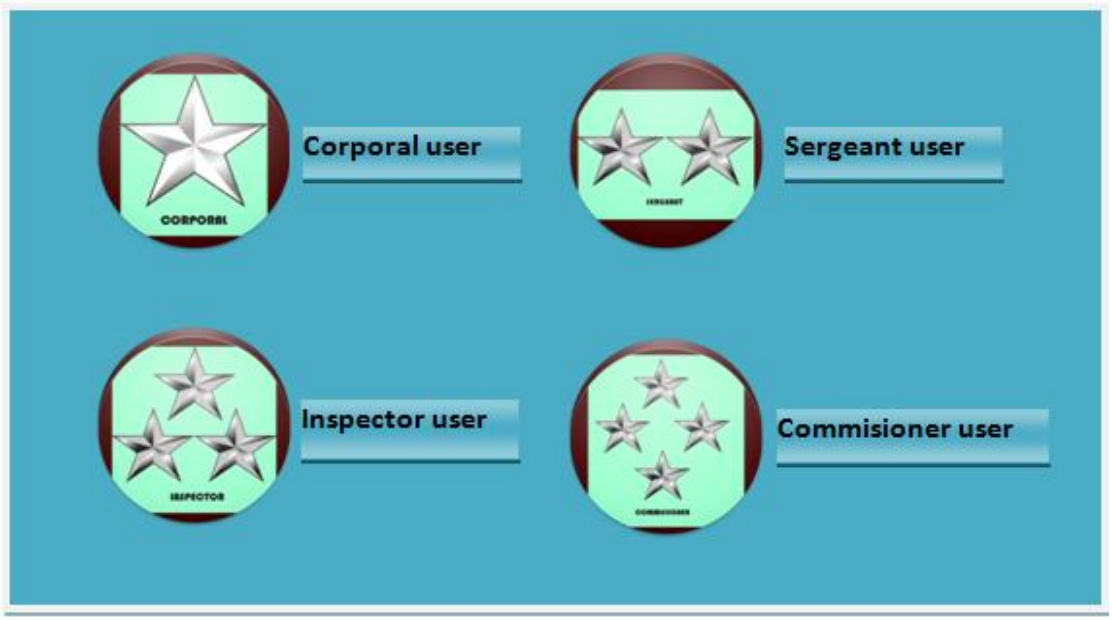

Figure 4.17: Ranks & Images

4.3 Summary

Overall, we use the algorithms that we discussed in previous chapter and we design and develop a mobile application for android devices. We described the technical architecture and the technologies that used in our system.

- The application is developed in Android
- In Spring's REST Template is based the mobile client
- Google map API v2 for the map
- JSON data types for data transfer
- The server is implemented in Tomcat
- MySQL v5.5 for database
- JAX-RS for web services
- JDBC for accessing the database
- Communication between server and mobile device is based on REST

After the technical architecture analysis we described the functional architecture of the system. We analyzed all the functions that used for the communication between

the client and the server. Furthermore, it is described the database of the system. The database has two tables, the “reports” table that stores all the information about the reports and the “users” table that stores the information about the users.

Finally, in the result sub-chapter we explained the activities, the functions and the methods we use in the mobile application and the functions and the methods in the server. Moreover, we depicted the Graphical User Interface of the application and we explained all the background communication between the client and the server.

Chapter 5

Evaluation

In the previous chapter we described with which tools we used to do the implementation for this project. We described the technical and functional architecture and the data structure of the system. Then, we showed all the GUI of the application and how the application works. In parallel we explained the required methods that needed in order to request from the client to server and to response back from the server to the client. In this chapter we will test our project by giving the application in ten users and then by asking them some question. Also, we will use some data from the transport department of U.K. in order to test the "trustiness" equation.

5.1 Evaluation overview

The evaluation of this project should have done under real circumstances, but two major factors hinder our initial plans. To evaluate such a project they would needed more than a hundred users who would have android phones that they would walk around the city reporting traffic incidents and reacting like real users. It was impossible to find so big number of volunteers and motivate them to participate without a reward. Secondly, we did not have plenty of time to organize an experiment like that.

Thereby, we will take different kind of scenarios where ten users will be asked to answer some questions. Firstly, we will evaluate the functionality and usability of the

application in order to test if the application reaches its initial goal which is “a traffic report application”. Secondly, we will evaluate the trustworthiness of the reports that will be published through this application. Third, we will examine in which degree the extra information (percentage of users, user who published the report) about the reports are useful to the users in order to lead them in right decisions. Fourth, we will evaluate the “trust” equation under different circumstances.

5.2 Equipment and limitations

In order to test and evaluate the performance of the application, a sample database is set up, where stored user’s account and traffic reports. The equipments which will be used to test the project are a LG Optimus L7 (P700) smartphone android version 4.0.1, a Belkin (model F6D4630) enhanced wireless modem/router and a Toshiba laptop (satellite A300). In the smartphone is needed to install the android application where the users will be able to utilize the application and test its functionalities. The router is needed to make the connection between the laptop and the mobile phone and simultaneously to provide connection to the internet. The laptop will be used as an API (Application Program Interface) server and it will communicate directly with the database.

In our experiment we will assume that there are not connection problems between the server and the mobile phone. Moreover, the mobile phone has internet access during the whole experiment without any problems. Moreover, we assume that the system does not crush and malware users cannot commit any attack in the system or in the database.

5.3 Scenarios and Evaluation

As we described in chapter 3 in order to achieve immediate and up-to-dated reports we publish all the reports without waiting to be confirmed from other users.

Thereby, the above policy creates issues concern with the trustworthiness of the reports. Trying to mitigate this gap in the system, we provide some extra information about the reports which we consider that they will be useful to the users in order to take correct decisions.

5.3.1 Functionality and Usability

In the first experiment we asked from ten volunteers to use the application in order to retrieve useful results concern with the functionality and usability of the application. We have to mention that we had given to them instruction as far as the application concern. Then, we asked them to do some tasks in order to evaluate our application.

Task	Percentage of Success
Make Registration	100%
Create Report	100%
Vote Report	90%
View My Profile	100%

Table 5.1: Tasks & Percentage of Success

The “make registration” task asked from the users to make a registration in the application. The “create report” task asked from the users to report a traffic incident through our application. The next task, “vote report” asked from the users to find a report and to give their vote about it (trust, untrust). Finally, we asked them to view their points and their rank. We can view from the above table that the users were able to accomplish each task with success without addressing any problems. Only in the task “Vote Report” one user faced problem to complete the task, due to the fact that he did not give attention during the guidance process. Moreover, seven volunteers complained about the “create report” functionality. They said that while they were trying to view the map, it appeared the “create report window” because

they clicked on the map by accident. General, they were satisfied with the application and propose some changed in the design but is not the main purpose of this project in order to pay more attention to the front end of the application.

5.3.2 Reports' trustworthy

In our second experiment we will try to evaluate if the given information about the reports (percentage, the name of the user who published this report) are useful to users in order to take correct decisions concern with the trustworthiness of the report. Thus, in our evaluation we will take different cases and then we will ask the volunteers if they trust or not the report.

Users' Percentage	Username	Number of volunteers (Trust)
0%	Known	**8**
1%	Known	**10**
2%	Known	**10**
0%	Unknown	**0**
1%	Unknown	**4**
2%	Unknown	**10**

Table 5.2: Table of Trustiness

The first column depicts the percentage of trustiness, videlicet the percentage of users who have voted as "trusted". The percentage of trustiness estimated as we showed in chapter 3. The second column depicts if the volunteers knows the user who uploaded the report. The third column shows the results, videlicet how many volunteers out of ten trusted the report if they knew the extra information (percentage, username) about the report.

From the above table we show that if the volunteers knew the user who uploaded the report, they trusted the report, even if the percentage was low. In the case where the percentage was zero, eight users trusted the report if they knew the

username and zero if they didn't know it. All the volunteers trusted the report in the case where the username was known and the percentage was five percent. On the other hand only four users trusted the report in the same percentage but without knowing the username. Finally, when the percentage was ten percent the volunteers trusted the report without carrying if they knew or not the username.

Due to the fact that some reports will be misleading causing confusion to the users, we will examine with the help of the above results if there is any case the users to trust a misleading report. Now according to the above results we can derive useful information about the trustworthiness of the reports. We assume that a malware user share a misleading information. Then, the "user's percentage" will be zero and he will be an unknown user. Thus, the other users will not trust this report as we showed in the above table, in the fourth case. Moreover, when other users vote a report as "untrust" and the number of votes is bigger than a threshold (as we explained in chapter 3), the report will be deleted. In the first and the second case we have achieved to create immediate and trustworthy reports. In other cases the report should be characterized as "trusted" in order the users to follow this report.

The case that a malware user will steal the username and the password from a common user, in order to mislead more users, it doesn't belong to the field study of this project.

Finally, the case that a group of malware users will publish the same report in order to achieve high percentage is very rare, if you imagine that in 1,000 users the 5% is 50 users. Thus, 50 malware users need them to publish the same report.

5.3.3 "Trust" Equation

In chapter 3 we have described the equation that is used to characterize a report as "trusted", without needing the extra information (percentage, username). We will evaluate this equation under different circumstances (time, road and region population density).

Time

In midweek the average number of vehicles for each mile at 2 o'clock was 10 thousands [43]. On the other hand in midweek the average number of vehicle for each mile at 16 o' clock was 210 thousands.

$$ratio = \frac{number\ of\ vehicle\ at\ 2\ o'clock}{number\ of\ vehicle\ at\ 16\ o'clock} = \frac{1}{21}$$

Thus, we assume that we have 1000 users at 16 o'clock and we need 10 (1% of 1000) users in order a report to be characterized as trusted. If we have 1000 users at 16 o'clock according to the above equation then we will have 48 users (1000/21) at 2 o'clock. In this case a report at 2 o'clock will not have the same chance to be characterized as "trusted".

- 10 users at 16 o'clock is 1% of the users
- 10 users at 2 o'clock is 20,83% of the users

Type of road

In 2010, on average, major roads in Great Britain had 12 times the flow of minor roads [43]. Thus, if we assume that we have 1000 in major streets then we need 10 (1% of 1000) users in order to be characterized a report as "trusted". Then in minor roads we will have 83 users (1000 / 12). In this case if a user publishes a report in a minor road, then the report will not have the same chance to be characterized as "trusted".

- 10 users at major road is 1% of the users
- 10 users at minor road is 12,04% of the users

Density

In this point we have to remind that the equation takes into account the number of users that belongs in a region. If we assume that we have 1,000 users in Dublin city then for a report to be characterized as "trusted", it will be needed 10 (1% of 1000) users. If we assume that in Cork city we have 500 users, then they will be needed 5 (1% of 500) users. As a consequence we perceive that the equation takes account

the density of the region expecting different number of users in order to characterize as “trusted” a report.

As we show in the department of transport in United Kingdom the annual vehicle flow is different at each road. Additionally, in some of them the traffic flow is larger than others. In our application this phenomenon has a serious impact.

5.4 Proposed method for “trustiness” equation

As we mentioned above the “trustiness” equation does not work properly in some cases. In the same street the flow is not the equal at midday and during the night. Also, major streets have bigger flow that minor streets. In this sub-chapter we propose a method in order to overcome the above problems.

Firstly, we should distribute this application in as many as possible users. The users will act as they act in their normal life. Thus, we will keep historical data from these users and will keep records for the flow in the each street and for the flow in each hour of day. By this way we will know for each hour the flow for each street.

The “trustiness” equation will take into account the location and the time of the incident and according to these data it will estimates the number of users are needed in order to be characterized a report as “trusted”. Thereby, the “trustiness” equation will work properly under different circumstances (time, location).

5.5 Conclusion

We have developed a mobile application that is easy to use, due to the fact that almost all volunteers were able to accomplish the main tasks. Also, we have achieved immediate reports in the cases where the username is known and the percentage is low. We mitigate the problem with the misleading reports. If someone uploads a misleading report the percentage will be 0% and he will not be known to

other users. In this case none of the volunteers trusted the report. Finally, the "trustiness" equation works properly only under specific circumstances, but we proposed a method to improve it.

Questionnaire

Please answer all the questions

❖ Functionality & Usability

Try to accomplish the below tasks in the application and answer if you succeeded or failed

Task	Success	Fail
Make Registration		
Create Report		
Vote Report		
View My Profile		

❖ Evaluate Report's trustworthy

Assume that you use this application in real world. Answer "trust" or "untrust" if you know the following information about a report

User's Percentage	Username	Trust	Untrust
0%	Known		
1%	Known		
2%	Known		
0%	Unknown		
1%	Unknown		
2%	Unknown		

Thank you for your help!

Chapter 6

Conclusion & Future Work

6.1 Conclusion

This thesis is based on a novel technique, participatory sensing, that exploits the power of the crowd. A mobile application designed and implemented that users can report traffic incidents in the streets and can be aware as far as the real situation in roads concern.

Alternative techniques proposed which aim to make faster the publication of the reports while giving the opportunity to users to evaluate the trustworthiness of the reports. The incentive methods, reward and rank not only utilized to motivate users to participate but also to enforce them to publish the reports immediately. Extra information is provided for each report that allowing to users to evaluate the trustiness of the report. The percentage of users who have already voted the report and the username of the user who published the report are the extra information. Moreover, a “trustiness” equation is proposed which takes as import some parameters (population density, number of votes) and exports if a specific report is trusted or not.

The results showed that the application is user-friendly and all the users are able to accomplish the main tasks easily. Moreover, the results indicated that in some cases the extra data are useful to participants and can trust the application achieving simultaneously immediate reports. The “trustiness” equation did not work properly under specific circumstances indicating it needs to be improved.

6.2 Future Work

First of all, as the chapter 5 indicated, it is necessary to be improved the “trustiness” equation. Time and road are parameters that equation should take into account. We proposed a method to overcome this issue, in 5.4.

Another possible improvement in the application will be to create something similar like social network. The users will be able to add friends in their network and to have more information about their friends. The users will recognize their friends easier and they will trust the report from their friends. Also, the users will be able to exchange messages and inform each for the real situation in the streets. We this method will try to create bindings between the users and motivate them to use more the application.

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