Sex Offender Watch: Developing and evaluating methods for visualizing registered sex offenders in Baton Rouge, USA, using Android smartphones

by

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2nd Bachelor Thesis

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Science Pledge

By my signature below, I certify that my thesis is entirely the result of my own work. I have cited all sources I have used in my theses and I have always indicated their origin.

Villach, 15.06.2013

Philipp Stiasny

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Zusammenfassung

Das United States Department of Justice and Watchsystems schätzt, dass sich in einem ein Meilen- Radius von 80% aller Wohnadressen mindestens ein Sexualstraftäter befindet. Mehr als die Hälfte aller Fälle von Vergewaltigung und sexueller Nötigung finden im Umkreis des ein Meilen Radius des Wohnortes des Opfers statt. Sexualstraftäter leben in den ärmsten und reichsten Stadtteilen und kommen in allen sozialen Schichten vor. In den USA existieren zwei Haupt Web-Plattformen, OffenderWatch® und DSNSOPW, die zentral Informationen über verurteilte Sexualstraftäter zur Verfügung stellen. Diese Arbeit beschreibt die Entwicklung von Methoden zur Visualisierung von Sexualstraftäterstandorten auf Android Smartphones, im Bezirk East Baton Rouge, Louisiana, USA unter Zuhilfenahme der OffenderWatch® und DSNSOPW Daten. Zu Beginn wird ein Location Based Service (LBS), basierend auf Heidmann's (1999) „question and answer modell of the cartographic information process" definiert und schrittweise umgesetzt. Das LBS wird durch einen Android-basierten mobilen Client, einer Web-Server-Schnittstelle in Verbindung mit einer Datenbank, die die Daten zu den verurteilten Sexualstraftätern enthält, charakterisiert um Informationen zu analysieren, zu lokalisieren, zu identifizieren und zu visualisieren. Aufgrund des Fehlens einer Schnittstelle für Smartphones zu den existierenden Web-Plattformen OffenderWatch® und DSNSOPW, wird eine Testdatenbank für den East Baton Rouge Bezirk entworfen und mit Testdaten eingesetzt. Als Ergebnis wird der Standort des Anwenders und der der verurteilten Sexualstraftätern innerhalb eines vom Benutzer definierten Suchradius auf dem Android Smartphone mit Google Maps API V2 visualisiert. Abschließend wird der entwickelte Prototyp auf Positionsgenauigkeit und Funktionalität im Außeneinsatz mit den Testdaten aus dem East Baton Rouge Bezirk validiert.

Abstract

The United States Department of Justice and Watchsystems estimate that 80% of all residential addresses in the USA have at least one sex offender within a one-mile radius of their homes. More than half of rape and sexual assault incidents happen within a one-mile radius of the victim's home. Sex offenders are living in the poorest and richest neighborhoods and across socio-economic boundaries. Two main web platforms provide convicted sex offender information, including OffenderWatch® and the Dru Sjodin National Sex Offender Public Website. This thesis develops methods for visualizing locations of registered sex offenders, using Android smartphones based on OffenderWatch® and DSNSOPW data, in the East Baton Rouge Parish, Louisiana, USA. In a first step, a location-based service (LBS) based on Heidmann's (1999) "question and answer model of the cartographic information process" is defined and implemented systematically. This LBS is characterized by an Android based mobile client, a webserver interface in combination with a database, containing convicted sex offender information, to analyze, locate, identify and visualize the information. Due to the lack of an interface for smartphones to the convicted sex offender data in the DSNSOPW and OffenderWatch® platforms, a test database model for the East Baton Rouge Parish has been developed and implemented. As a result, the Android prototype visualizes the user's location and the locations where the convicted sex offenders live, within a user defined mile radius on Android Google Maps API V2. Finally, a prototype test, regarding the positional accuracy and the functionality with the sex offender data from East Baton Rouge is conducted in the field.

Table of Contents

List of Abbreviations

AGPS	*Assisted Global Positioning System*
API	*Application Programming Interface*
FBI	*Federal Bureau of Investigation*
GSM	*Global System for Mobile*
GPS	*Global Positioning System*
GPRS	*General Packet Radio System*
HTTP	*Hypertext Transfer Protocol*
NCMEC	*National Center for Missing & Exploited Children*
NICTS	*New Information and Communication Technologies*
NSOPR	*National Sex Offender Public Registry*
DSNSOPW	*Dru Sjodin National Sex Offender Public Website*
LTE	*Long Term Evolution*
NIPF	*Notification is Prevention Foundation*
NSOR	*National Sex Offenders Registry*
OS	*Operating System*
SMS	*Short Message Service*
SORNA	*Sex Offender Registration and Notification Act*
SSL	*Secure Sockets Layer*
UI	*User Interface*
UML	*Unified Modeling Language*
UMTS	*Universal Mobile Telecommunication System*
WC	Wireless Communication
WGS84	World Geodetic System 1984
WLAN	Wireless Local Area Network
XML	Extensible Markup Language

1. Introduction

As the title of this thesis already says, appropriate methods for visualizing the locations of convicted sex offenders on map services using Android smartphones are evaluated and a software prototype is developed. In the following subchapter, the motivation to do this kind of research, the problem definition, the solution methods and the expected results are discussed. Finally, an overview of the thesis structure is given in the end of this chapter.

1.1. Motivation

The National Center for Missing & Exploited Children (NCMEC) showed that in 2010, there were 722,499 registered sex offenders in the United States (Figure 1). The majority of sex offenses, 80% - 95%, are committed by someone the victim knows. Sex offenders usually do not commit their crimes impulsively, they carefully plan their crimes. Many offenders have no official criminal record or sex crime history of any kind. There exists no typical sex offender, as they come from all backgrounds, ages, income levels, and professions. Research shows that most convicted sex offenders have committed many, many sex offenses before they are being caught (Sherrif Alerts, 2012).

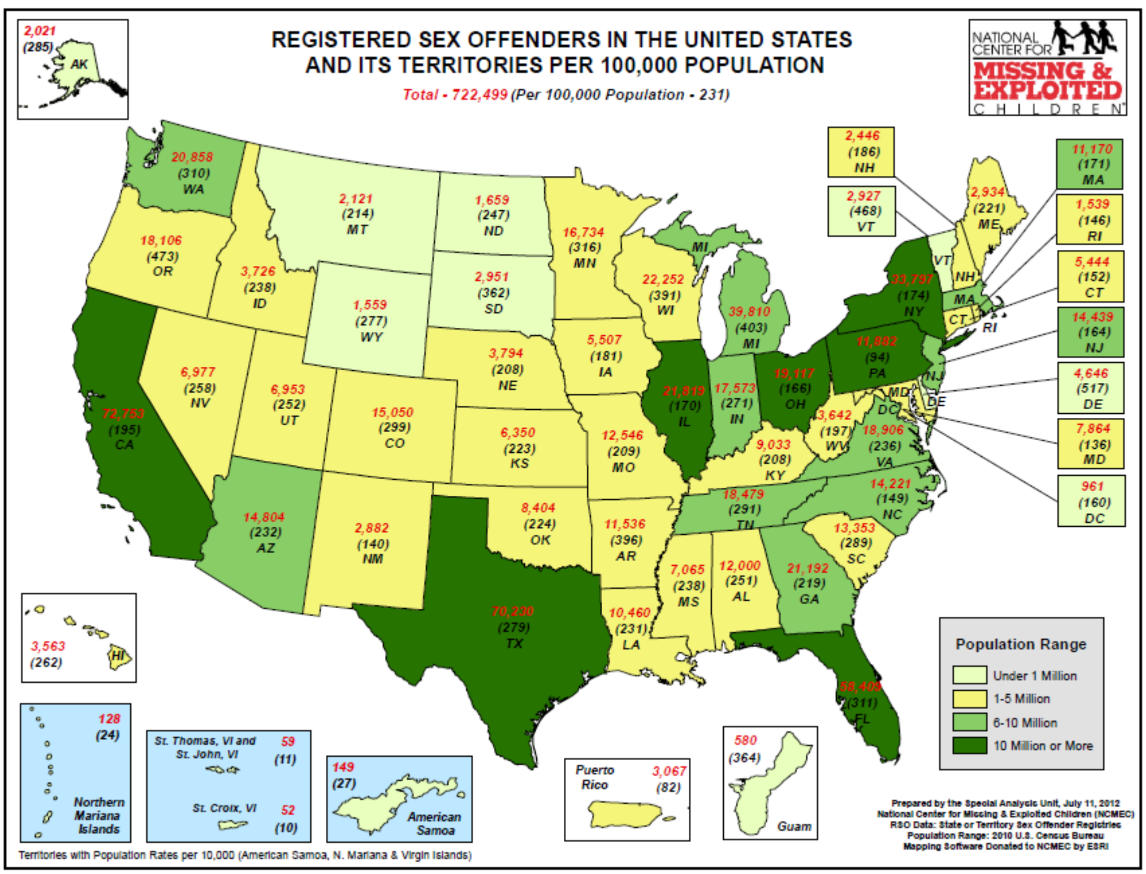


Figure 1: Registered Sex Offenders in the United States in 2010

In 2006, the former president of the United States George W. Bush signed into law the Adam Walsh Child Protection and Safety Act, which includes a law to honor the memory of Dru Katarina Sjodin. Dru Katarina Sjodin was a young woman, born 1981 in Minneapolis, Minnesota. On the evening of November 22, 2003, after Sjodin was leaving work, she went missing. Police investigations led police to Alfonso Rodriguez, a level 3 Minnesota registered sexual offender, who had been released from prison six months before Dru Katarina Sjodin's disappearance. Sjodin's body was found five months after Rodriguez's arrest. Rodriguez was tried and found guilty in Dru Katarina Sjodin's abduction and sentenced to death under federal law because he had crossed state lines in order to commit the crime (DSNSOPW, 2012).

The Adam Walsh Child Protection and Safety Act, which includes the law to honor Sjodin that changed, among other things, the name of the National Sex Offender Public Registry (NSOPR) to the Dru Sjodin National Sex Offender Public Website (DSNSOPW). The DSNSOPW, coordinated by the U.S. Department of Justice, is a cooperative between jurisdictions hosting public sex offender registries and the federal government that provides information on the whereabouts of registered sex offenders regardless of state boundaries and free of charge to the public (DSNSOPW, 2012).

Additionally, there is OffenderWatch® – USA's leading registered sex offender management and community notification tool. Both the OffenderWatch and the DSNSOPW are web-based platforms and provide useful information for the people, where registered sex offenders live and which areas maybe "endangered" with the offenders sphere of influence. That is why it is very interesting and beneficial to develop and evaluate suitable visualization methods of the OffenderWatch® and the DSNSOPW data for integration into mobile devices, based on the Android smartphone platform.

1.2. Problem Definition

Unfortunately, the DSNSOPW and OffenderWatch® platforms are web based and designed for the use with computers or devices with larger displays. For this reason, a native mobile application is very useful, when it comes to situations where people need to get information instantly and on the fly. For example, when a family is shopping for a new home and wants to know, if there are currently any registered sex offenders living in the neighborhood of the new home. Another example is that registered sex offenders live close to certain locations that children use when they commute to school (e.g. bus stops).

1.3. Methods of Solutions

The aim of this thesis project is to develop a native Android prototype software client that uses the existing data from the sex offender's web platforms. East Baton Rouge parish is defined as the test area and the data of the web platforms will be built in a test database, since there does not yet exist an interface for smartphones. To achieve the objectives, evaluations for the most suitable map service for the Android operating system (OS) platform have to be made. With the use of smartphones' internal Global Positioning Systems (GPS) receiver and a data connection via radio network or wireless local area network (WLAN), the user's location can be determined within an accuracy of 10 meters (Zogg, 2011). As a result, the Android prototype visualizes the user's location and the locations where the convicted sex offenders live, within a chosen radius on a map. Based on the users' choice further information of sex offenders can be retrieved and will be provided in a list view. Additionally, functions will be implemented that allow the user to search for sex offenders within a defined distance of the actual location.

1.4. Expected results

The expected results of this thesis are:

- Developing an Android based prototype on the client side.
- Building a manually populated test database with data of convicted sex offender's from the East Baton Rouge Parish to test the Android client.
- Development of an interface on the server side for geospatial queries of the database.
- Conducting a prototype test regarding the positional accuracy and the functionality with the sex offender data from East Baton Rouge.

1.5. Structure of the Thesis

The following sections of this thesis are built upon each other and provide a scientific approach to solve the problem definition. Chapter two provides a brief introduction in the theoretical background of the sex offender situation in the United States of America and basic technical background knowledge of smartphones and positioning methods. Furthermore, chapter three describes the project area, the used data and its quality. Chapter three also contains the implementation with the appropriate technologies. Chapter four deals with the implementation results that are critically discussed in chapter five. A summary, the conclusions, and an outlook is provided in chapter six. Finally, chapter seven, eight, and nine lists all references, figures, and tables contained in this work.

2. Theoretical background

The theoretical background section provides basic knowledge about sex offender classifications and sex offender registries in the United States and in the federal state of Louisiana. In addition to that a brief introduction into the residency restrictions and the sex offender recidivism is given. Finally, the principles of positioning and a brief introduction to smartphone and Android technologies are given.

2.1. Sex offenders

Sex offenders have become a major issue for policy makers in the United States of America because they pose a threat to the public. The development of sex offender registries and laws restricting where registered sex offenders may live, work, and travel were intensified in the last two decades (DSNSOPW, 2012).

2.1.1. National Sex Offenders Registry

The state of Louisiana enacted its first law, mandating the registration of persons convicted of sex offenses and offenses against victims who are minors, in the year 1992. Back then, local sheriffs' offices and police departments did the registration of convicted sex offenders by forwarding the fingerprints and related information to the Department of Public Safety and Corrections at the Office of State Police. As the United States Congress enacted the Wetterling Act in 1994, guidelines for the states sex offender registration programs were set (Louisiana State Police, 2010).

The Federal Bureau of Investigation (FBI) Headquarters coordinated the development of the National Sex Offenders Registry (NSOR) upon the Pam Lychner Sexual Offender Tracking and Identification Act of 1996. The objective was to establish a national database for tracking the whereabouts and movements of convicted sex offenders, who had committed a criminal offense against a minor victim, a sexually violent offense, or were sexually violent predators. Laws were passed that made it a criminal offence for registered sex offenders to move to another state or establishing a new residence and knowingly fail to notify the FBI and the local authorities within 10 days (The FBI - Federal Bureau of Investigation, 2012).

In 2005, the Department of Justice installed the National Sex Offender Public Website (NSOPW), the first sex offender database accessible over the internet. It was renamed to DSNSOPW in 2006 through the Dru Sjodin act from 2003 (The United States Department of Justice, 2012). Based on the Adam Walsh act or also known as the Sex Offender Registration and Notification Act (SORNA), in 2006 changes were made in terms of initial registration, keeping the registration current and the state penalty for complying failures (109th United States Congress, 2006).

„A sex offender shall register, and keep the registration current, in each jurisdiction where the offender resides, where the offender is an employee, and where the offender is a student. For initial registration purposes only, a sex offender shall also register in the jurisdiction in which convicted if such jurisdiction is different from the jurisdiction of residence. " (109th United States Congress, 2006)

The state of Louisiana amended the existing sex offender registration in conformity with the new Adam Walsh Act in 2008 (Louisiana State Police, 2010).

2.1.2. Sex offender classification

The Adam Walsh Act organizes sex offenders into three tiers. In this subchapter, only the related tiers and criminal codes for the state of Louisiana are listed and there might be differences compared to other state jurisdictions in the United States.

TierI Sex Offender: *"A person convicted of committing or attempting to commit any of the following enumerated sex offenses or a comparable offense under the laws of another state. All offenses requiring registration other than those defined in 15:541 as "aggravated offenses" or "sexual offenses against a victim who is a minor" will have a* ***15-year registration period****. To be conducted annually"* see Table 1: TierI - Sex Offenses .

Table 1: TierI - Sex Offenses (Louisiana State Police, 2010)

Statute	Description
14:43(A)(3)	Simple Rape under subsection (3)
14:43.1	Sexual Battery of Victim 18 and over
14:43.5	Intentional Exposure to Aids
14:45.1	Interference with child custody - other than by parent
14:46	False Imprisonment of child under 18 - other than by parent
14:46.1	False Imprisonment of child under 18 with weapon
14:78	Incest
14:80	Felony Carnal Knowledge (except if waived by court pursuant to 15:542(F)(2)
14:81	Indecent Behavior with Juveniles
14:81.4	Prohibited Sexual Conduct between educator and student
14:89	Crime Against Nature
14:92(A)(7)	Contributing to the Delinquency of Juveniles
14:106(5)	Obscenity through solicitation of a minor
14:283	Video Voyeurism
14:283.1	Voyeurism
23:251	Minors under 16: prohibited employments or occupations

„Sex offenses against minors are defined as criminal offenses against a victim who is a minor when the victim is under the age of 18 and the person is not the parent of the victim. A person convicted of one of the following offenses when the victim is a minor and not the child of the offender is a Child Predator" (Louisiana State Police, 2010).

Tier II Child Predator: *"A person convicted of committing or attempting to commit any of the following enumerated offenses or a comparable offense under the laws of another state when the victim is a minor and the defendant is not the parent of the victim. All offenses defined in 15:541(9.1) as "sexual offenses against a victim who is a minor" will have a* ***25-year registration period****. To be conducted semi-annually"*, see Table 2: TierII - Sex Offenses .

Table 2: TierII - Sex Offenses (Louisiana State Police, 2010)

Statute	Description
14:43.1	Sexual Battery of Minor under 18 years of age
14:43.3	Oral Sexual Battery
14:46.2(B)(2)	Human Trafficking
14:78.1	Aggravated Incest under circumstances not in Tier III
14:81.1	Possession, Production and/or Distribution of Child Porn
14:81.2	Molestation of a juvenile or a person with a physical or mental disability (R.S. 14:81.2), except when prosecuted under the provisions of R.S. 14:81.2(C)(1), (D)(1), or (D)(2)
14:81.3	Computer Aided Solicitation
14:82.1	Prostitution: Persons Under Seventeen
14:83	Soliciting for prostitutes when the persons being solicited for prostitution are under the age of 18 years
14:83.1	Inciting prostitution when the prostitution involves persons under the age of eighteen years.
14:83.2	Promoting prostitution when the prostitution being promoted involves persons under the age of eighteen years
14:84 (1),(3),(5), and (6)	Pandering when victim is under 18 years of age
14:86	Enticing of minor into Prostitution
14:282	Operation of places of prostitution when the prostitution involves persons under the age of eighteen years

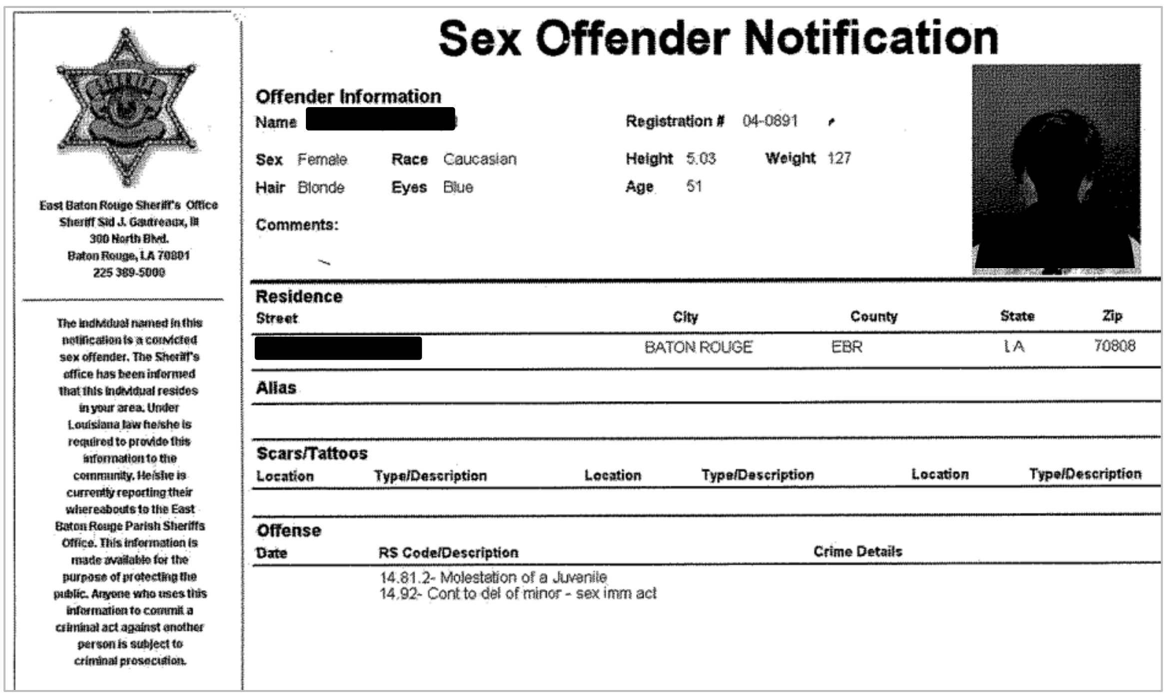
Tier III Aggravated Offense: *"A person convicted of committing or attempting to commit any of the following enumerated sex offenses or a comparable offense under the laws of another* *state. All offenses defined in 15:541(1) as "aggravated offenses" will have a* ***lifetime registration period****. To be conducted quarterly",* see Table 3: TierIII - Sex Offenses .

Table 3: TierIII - Sex Offenses (Louisiana State Police, 2010)

Statute	Description
14:42	Aggravated Rape
14:42.1	Forcible Rape
14:43	Simple Rape under subsection A(1) and (2)
14:43.1(c)(2)	Sexual Battery of a child under the age of 13
14:43.2	Second Degree Sexual Battery
14:44	Aggravated Kidnapping of a minor
14:44.1	Second Degree Kidnapping of a minor under 18
14:44.2	Aggravated Kidnapping of a child
14:45	Simple Kidnapping of a minor under 18
14:46.3	Trafficking of children for sexual purposes
14:78.1	Aggravated Incest involving sexual intercourse, 2nd degree sexual battery, or oral sexual battery
14:81.2(E)(1)	Molestation of a juvenile or a person with a physical or mental disability prosecuted under the provisions of R.S. 14:81.2(C)(1), (D)(1), or (D)(2)
14:89.1	Aggravated Crime Against Nature
14:93.5	Sexual Battery of the Infirmed

2.1.1. Sex Offender Notification

In the United States of America, the nonprofit organization Notification is Prevention Foundation (NIPF) works in partnership with Watch Systems, LLC, to provide sex offender information to the public. NIPF was founded to assist law enforcement agencies such as sheriff offices to provide email or active direct mail services that informs about the danger of a convicted sex offender living in the neighborhood and to provide safety tips to the residents. The NIPF sends mailings on 8 ½ x 5 ½ cardstocks, with the responsible sheriff's office logo printed on it to lend it credibility, see Figure 2 and Figure 3.



East Baton Rouge Sheriff's Office
Sheriff Sid J. Gautreaux, III
300 North Blvd.
Baton Rouge, LA 70801
225 389-5000

The individual named in this notification is a convicted sex offender. The Sheriff's office has been informed that this individual resides in your area. Under Louisiana law he/she is required to provide this information to the community. He/she is currently reporting their whereabouts to the East Baton Rouge Parish Sheriffs Office. This information is made available for the purpose of protecting the public. Anyone who uses this information to commit a criminal act against another person is subject to criminal prosecution.

Sex Offender Notification

Offender Information

Name [redacted] Registration # 04-0891

Sex Female Race Caucasian Height 5.03 Weight 127

Hair Blonde Eyes Blue Age 51

Comments:

Residence

Street	City	County	State	Zip
[redacted]	BATON ROUGE	EBR	LA	70808

Alias

Scars/Tattoos

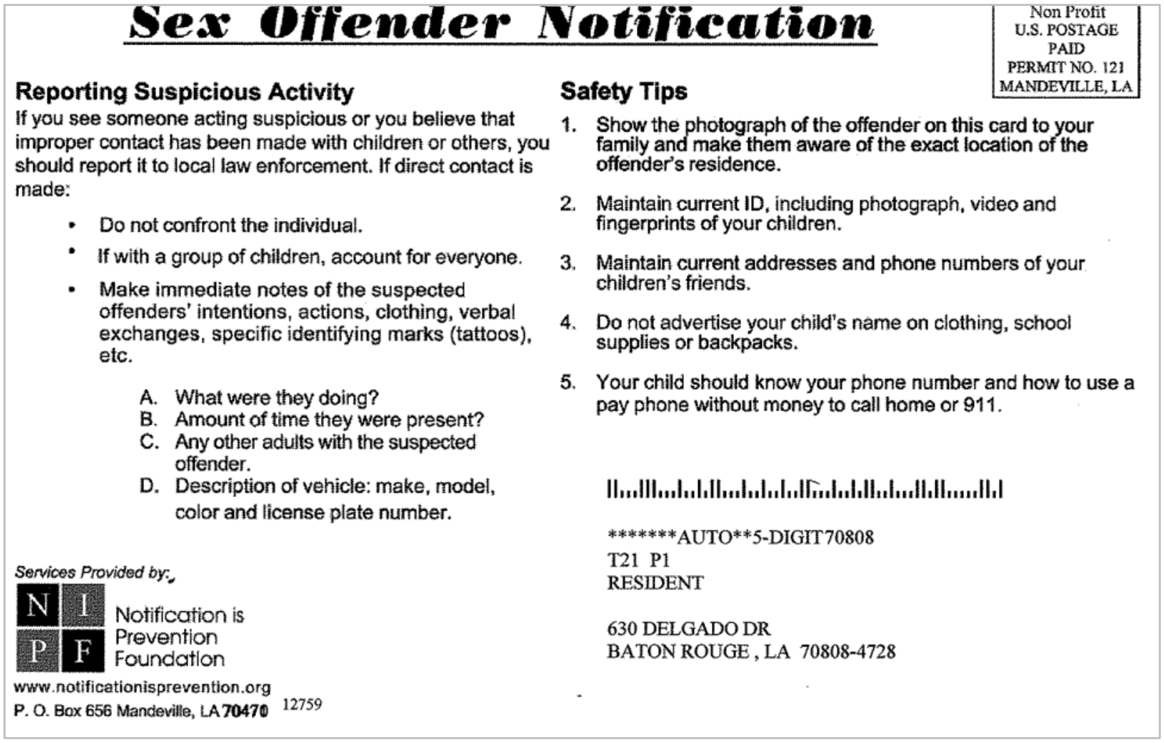
Location	Type/Description	Location	Type/Description	Location	Type/Description

Offense

Date	RS Code/Description	Crime Details
	14.81.2- Molestation of a Juvenile 14.92- Cont to del of minor - sex imm act	

Figure 2: Postal mail - sex offender notification – offender information

The addresses for the mailing actions are determined by a radial map method, in feet or miles around offenders' addresses. It takes 24 to 48 hours to send the postcards to the affected residents after the law enforcement agency publishes the sex offender data to the NIPF. Regarding to the NIPF website, the average sex offender mailing notification is 30 per day with an average of 400 mail pieces per offender. Furthermore, NIPF says that annually the mailings exceed 3 million notifications in the United States of America (NIPF, 2009).



Sex Offender Notification

Non Profit
U.S. POSTAGE
PAID
PERMIT NO. 121
MANDEVILLE, LA

Reporting Suspicious Activity

If you see someone acting suspicious or you believe that improper contact has been made with children or others, you should report it to local law enforcement. If direct contact is made:

- Do not confront the individual.
- If with a group of children, account for everyone.
- Make immediate notes of the suspected offenders' intentions, actions, clothing, verbal exchanges, specific identifying marks (tattoos), etc.

  A. What were they doing?
  B. Amount of time they were present?
  C. Any other adults with the suspected offender.
  D. Description of vehicle: make, model, color and license plate number.

Safety Tips

1. Show the photograph of the offender on this card to your family and make them aware of the exact location of the offender's residence.
2. Maintain current ID, including photograph, video and fingerprints of your children.
3. Maintain current addresses and phone numbers of your children's friends.
4. Do not advertise your child's name on clothing, school supplies or backpacks.
5. Your child should know your phone number and how to use a pay phone without money to call home or 911.

*******AUTO**5-DIGIT 70808
T21 P1
RESIDENT

630 DELGADO DR
BATON ROUGE , LA 70808-4728

Services Provided by:
N I P F
Notification is Prevention Foundation
www.notificationisprevention.org
P. O. Box 656 Mandeville, LA 70470 12759

Figure 3: Postal Mail - sex offender notification - safety tips

2.1.2. Residency Restrictions and Sex Offender Recidivism

Meloy et al. (2008) say that the legislations in more than 25 US states prohibits convicted sex offenders to live within a radius of 500 to 2,500 feet of locations where children congregate such as schools, playgrounds, and day care facilities. Those restrictions were enacted in law to prevent sex offenders from gaining access to potential victims. Moreover, they say that researches found out, that those residency restrictions lead convicted sex offenders to move from urban areas to locations that are more rural. An investigation of the Minnesota Department of Corrections (2003) found out that high-risk sex offenders did not reoffend more frequently when they lived in close proximity to schools or parks, compared to high-risk sex offenders, who did not live in close proximity to those locations.

A study of Duwe et al. (2008) examined 224 sex offenders out of 3,166 that were released from prison between 1990 and 2002 and recommitted new offenses before 2006. Duwe and his colleagues analyzed if the residency restrictions and geographical relations had affected the new offenses. Relations such as the offender's residence location, the location of the first contact with the victim, and the location where the offender committed the offense. Furthermore, the authors checked the victim's relationship with the offender, if force such as weapons or hand assault was used or if the victim or offender was influenced by drugs or alcohol.

The results showed that the restriction laws could have prevented none of the 224 sex offenses. In 10 of 13 cases, the victim was an adult and in the remaining three cases, two of the juvenile victims were in romantic consensual relationships with the offender, and in the third case, the victim met through the offender's occupation. None of the sex offenders were violating the restriction law. The researchers also said that in 79 cases, where the exact distance from the offender's home to the first contact location was known, 28 offenders met their victims within 1 mile, 21 within 0.5 mile and 16 within 0.2 mile, see Figure 4.

Table 1. Offender Residence—First Contact Distances for Direct-Contact Offenders

Distance	Number	Percent
Less than 1,000 ft. (0.19 miles)	16	20.3
1,000–2,500 ft. (0.20–0.47 miles)	5	6.3
2,501–5,280 ft. (0.48–0.99 miles)	7	8.8
1–2 miles	6	7.6
3–5 miles	10	12.7
6–10 miles	4	5.1
11–20 miles	4	5.1
Greater than 20 miles	7	8.8
Telephone	4	5.1
County Jail/Halfway House	2	2.5
Internet	1	1.2
Unknown	13	16.5
Total	79	100.0

Figure 4: Sex offender residence distance to first contact location, source Duwe, 2009

It turned out that the sex offender's recidivism was affected by social or relational and not by the residential proximity. The researchers found out that most of the victims were someone that the offender knew and 85 percent of the offenses took place in a residential location such as the offender's home. In 113 of the 224 cases, the offenders built relationships to other persons, for example women with children, to gain access to their juvenile victims. On top of that, the researchers found out that the sex offenders established direct contact mostly within areas of 20 miles of their neighborhoods (see Figure 4), but far enough away that they were not recognized by their neighbors (Duwe, 2009).

Finally, Duwe et al. (2008) show that the residency restriction limits the places where the convicted sex offenders can live, but it also makes it more difficult to monitor them. They also say that these restrictions force the convicted sex offenders to live in the uninhabited rural countryside, high-crime urban areas, business and commercial districts, or other locations with few housing options or make the convicted sex offenders to report false addresses to avoid monitoring. In addition to that Wilson (2009) argued that the restrictions are not supported by crime theory because convicted sex offenders do not choose their residence by places that are endangered, such as schools, but rather than by what they can afford. Wilson (2009) also says that even if sex offenders live near schools or day care facilities, a crime occurs only when a motivated offender finds a target that is not cared by a capable guardian.

2.2. Smartphone

At first, there were the mobile phones, also known as cellular phones, cell phones, or hand phones technology, which are devices that can only provide basic functionalities such as telephony or short message services (SMS) via a radio link that is connected to a cellular base network. In other words, the name mobile phone comes from the mobility that the radio link provides when moving around in a wide geographic area. The term smartphone describes devices that combine telephony and computing and was already conceptualized in 1973. However, the term appeared the first time in 1997 as the mobile phone manufacturer Ericsson described one of its phones as "smart" (Figure 5) because of the advanced computing capability compared to a normal mobile phone (Wikipedia, 2013).

Definition: *"A smartphone is a mobile telephone with computer features that may enable it to interact with computerized systems, send e-mails, and access the web"* (The Collins English Dictionary, 2013)

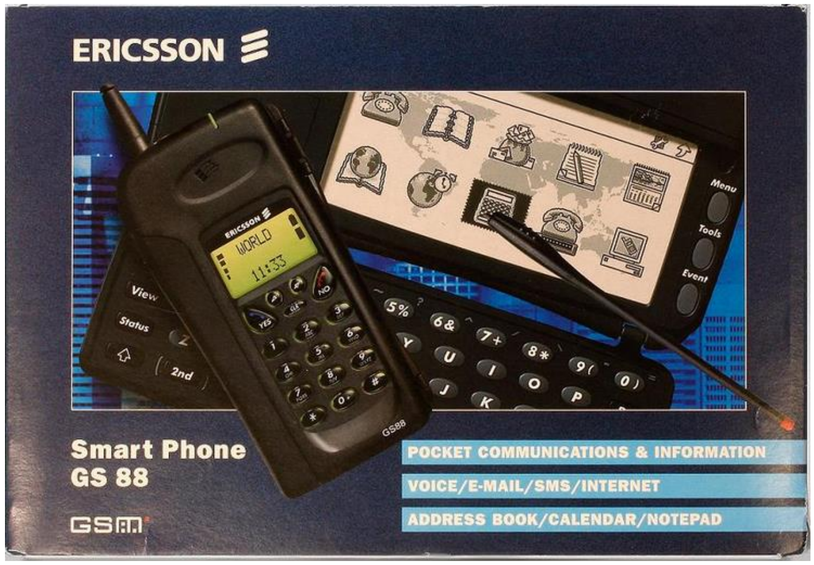


Figure 5: Ericsson Smart Phone GS 88 (Stockholm Smartphone, 2010)

At the beginning, smartphones were mainly used by business-oriented users as an extension to their mobile offices, to send or receive emails when they were on the way and had no access to their computers. Later when multimedia features such as playing videos, games, displaying photos, and accessing the internet on a larger display screens arose, the demand for smartphones by the consumers increased rapidly (Techterms, 2010).

According to Komatineni & MacLean (2012) nowadays there exists a great variety of smartphones with different operating systems (OS), such as Google's Android, Apple's iOS, Symbian OS, RIM's Blackberry OS, Microsoft's Windows Phone OS, Mobile Linux, Intel's Moblin, and others. In other words, due to diversity of smartphone OS, there is no de facto standard.

2.2.1. Smartphones market shares

The analysis of Young, et al.(2011) showed that the mobile phone market has changed from a new purchase market to a replacement market when smartphones came into the spotlight in the late 1990's.Nokia was dominating the smartphone market since the year 2000 with its Communicator devices that were based on the Symbian OS. In 2007, Apple released its first iPhone with a multi-touch interface and iOS platform. The first Android OS based smartphone came with the T-Mobile G1 in 2008 on the market. Since then the smartphone market grew very fast every year. With reference to Gartner Inc. (2013) worldwide smartphone sales to end users market shares show that smartphones with Android operating systems were more than 50% of the market in the fourth quarter of 2011 and captured 70% in the fourth quarter in 2012 (Table 4). As shown on Figure 6, Android is the most widely used smartphone OS on the worldwide market and has more than three times the market share compared to the second largest smartphone OS manufacturer Apple, with its iOS.

Table 4: Worldwide Smartphone Sales to End Users by Operating System in fourth quarter 2012 and fourth quarter 2011 (Thousands of Units) (Gartner Inc., 2013)

Operating System	4Q12 Market Share (%)	4Q11 Market Share (%)
Android	69.7	51.3
iOS	20.9	23.6
Research In Motion	3.5	8.8
Microsoft	3.0	1.8
Bada	1.3	2.1
Symbian	1.2	11.6
Others	0.3	0.8
Total	**100.0**	**100.0**

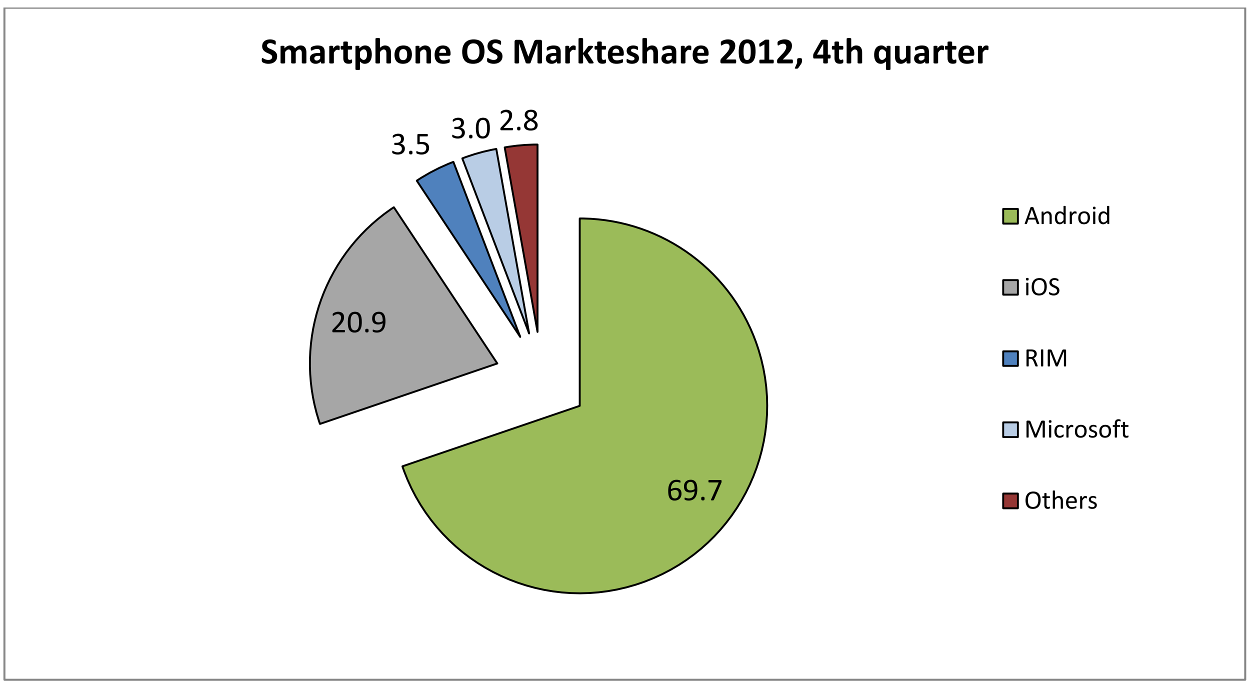


Figure 6: Worldwide smartphone operating system market share fourth quarter 2012 (in percent)

A study made by comScore Inc. (2012) over a three-month period from October2012 to January 2013 showed that more than 129.4 million people in the United States of America owned smartphones and that Google's Android was the leading smartphone OS platform with a 52,3 percent market share (Table 5). Even though Apple's iOS had a higher market share in the United States with 37.8 percent, than worldwide, it was still below Androids share (Figure 7). RIM ranked third with a 5.9 percent share, followed by Microsoft (3.9 percent) and Symbian (1.4 percent).

Table 5: Smartphone OS subscribers market share total United States, ages 13+, 3 months average Oct 2012 - Jan 2013, source comScore Inc.MobiLens, 2013

Operating System	Share (%) of Smartphone Subscribers		
	Jan-2013	Oct-2012	Point Change
Android	52.3	53,6	-1.3
iOS	37.8	34.3	3.5
RIM	5.9	7.8	-1.9
Microsoft	3.1	3.2	-0.1
Symbian	0.5	0.6	-0.1
Total	100.0	100.0	N/A

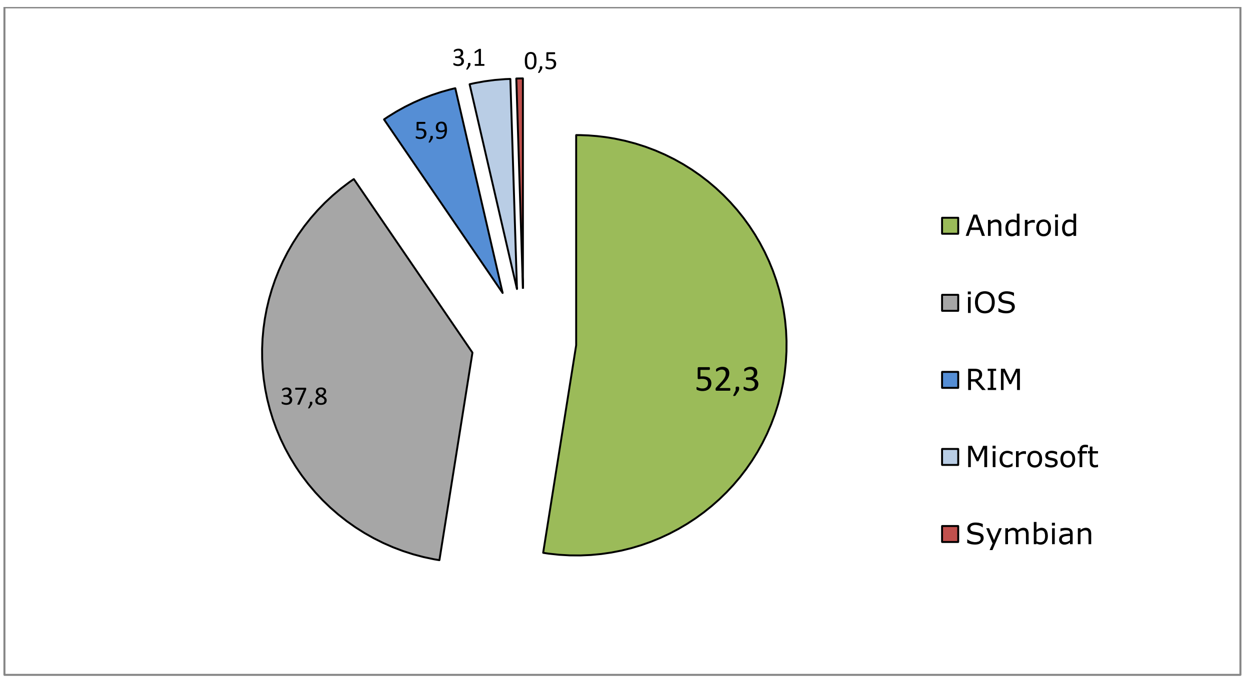


Figure 7: United States smartphone operating system market share January 2013 (in percent)

2.3. Android

"The Android platform stands for openness, affordability, open source code, and, more important, a high-end, all-in-one-place, consistent development framework" (Komatineni & MacLean, 2012).

In the year 2005, the startup company Android Inc., which was acquired by Google, started to develop the Android operating system (OS) platform. The Android OS platform is based on a modified, free and open source Linux kernel (see Figure 8).Furthermore, libraries programmed in C and C++ are used such as OpenGL, Web Kit, FreeType, Secure Sockets Layer (SSL), the C runtime library, SQLite, and Media Framework (Figure 8). Android devices also include applications (see Figure 8), programed in the object oriented (OO) program language Java, to cover functionality such as telephony, video, speech, graphics, connectivity, user interface (UI) programming, and a number of other aspects, which are running on a virtual machine, see Figure 8 (Komatineni & MacLean, (2012), Butler, (2011)).

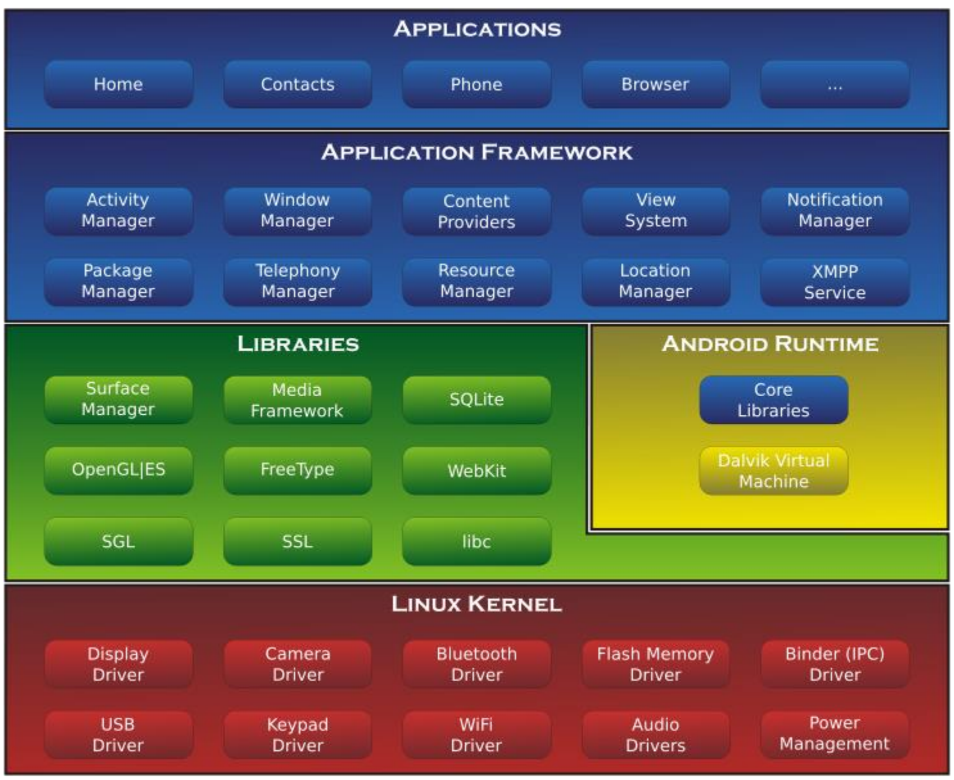


Figure 8: Android architecture with Linux kernel, C++ and Java libraries, source: elinux.org(2011)

According to Komatineni& MacLean (2012) Androids key architectural goals are to allow applications to interact with one another. In addition to that applications are reusing components from one another, not only as services, but also with data and the user interface.

The work of Xianhua and Zhenjun (2009) shows that Android supports GPS, video camera, compass, and 3d-accelerometer and provides rich application programming interfaces (APIs) for mapping and location functions. They say that users can flexibly access, control, and process the free Google map services and implement location based mobile services. As a result, the Android platform helps to reduce development costs and enables developers to form their mobile systems with unique characteristics (Xianhua & Zhenjun, 2009).

2.3.1. Android application components

Referring to Vogel (2013), Android uses different types of components to provide interaction between software elements. The main components are activities, intents, services, and layouts. Activities are the visual representations of Android applications and use views in combination with buttons, text fields, and layouts to create the user interface. Intents are asynchronous messages that allow the application to interact with other Android applications or to request functionality from other Android components such as services or activities (Vogel, 2013).

2.3.2. Smartphone connectivity

A smartphone device may have several interfaces for wireless data communication. Based on the smartphones telecommunication provider, used technology different generations (G) of radio signal services are used. Each generation in Table 6 is the continued development of its predecessor and newer smartphones are backward compatible but not vice versa. In rural and less densely populated areas, the used technology generation may be older and resulting in a slower data transfer rate than in tightly populated areas.

Table 6: Base station transmission technology, Elektronik-kompendium (2013)

Generation	Name	Bandwidth
1G	AMPS - Advanced Mobile Phone System	
2G	GSM - Global System for Mobile Communication	9,6 kBit/s
2,5G	GPRS - General Packet Radio Service	115 kBit/s
2,75G	EDGE - Enhanced Data rates for GSM Evolution	236 kBit/s
3G	UMTS - Universal Mobile Telecommunication System	384 kBit/s
3,5G	HSPA - High Speed Packet Access	14,4 MBit/s
4G	LTE - Long Term Evolution	1 GBit/s

Several new smartphones also provide Wi-Fi functionality. WI-FI is the name of a registered trademark and stands for a radio signal based Wireless Local Area Network technology on IEEE 802.11x standards that provides high-speed Internet or network access.

2.4. Positioning methods

In general, positioning can be divided into network-based and terminal based methods (Steininger, et al., 2012). However, a hybrid method, which is a combination of network and terminal based methods, has mainly prevailed in the smartphone sector since 2009.In the following subchapters, each of these positioning methods is briefly described and illustrated.

2.4.1. Network based

Referring to Steininger et al. (2012) the network based method uses wireless communication networks such as the Wide Wireless Area Networks (WWAN) of telecommunication providers for locating the position of a device. In addition to that, also Wireless Local Area Networks (WLAN), if the exact location of the WLAN base station is known, can be used for localizing. With the use of the cell of origin (COO) technique, the nearest base station to the smartphone’s location can be determined in the communication network. Telecommunication providers may use different technology generations of services e.g. GSM, UMTS or LTE to provide network coverage. However, those base stations have known locations with coordinates and therefore, according to Zhang et al.(2012), an approximate location of the smartphone in the network can be determined via e.g. GSM footprints from the telecommunication base stations (see Figure 9).

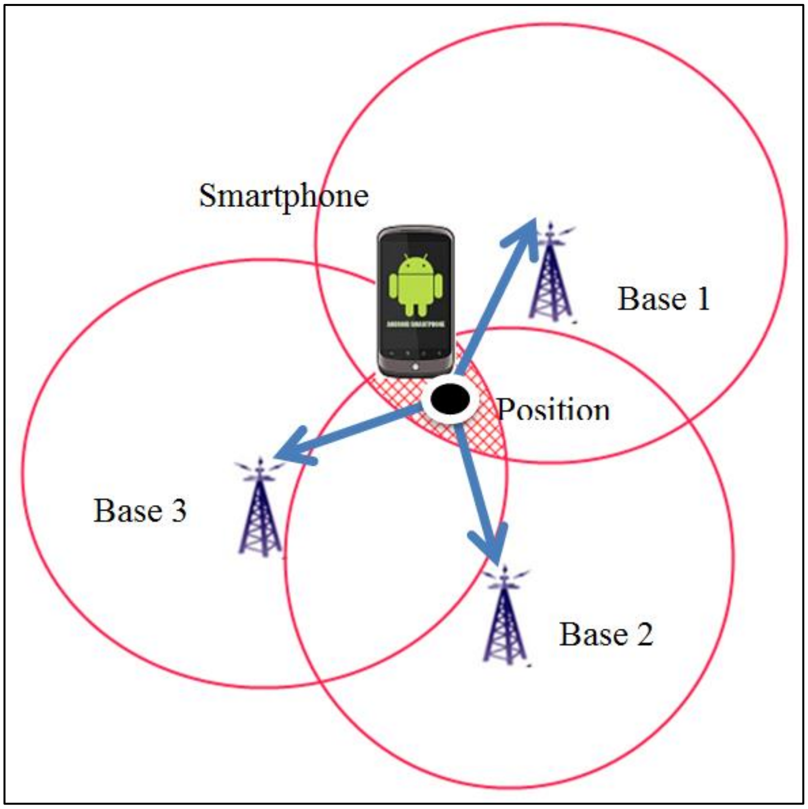


Figure 9: Network based positioning, source Stiasny (2013)

2.4.2. Terminal based - GPS

In the terminal based method the smartphone calculates the location via trilateration of several signals that were received from base stations, from for example the Global Positioning System (GPS) (Steininger, et al., 2012). GPS is a technology based on satellites emitting radio signals that allow users to determine their current exact location anywhere in the world, 24 hours a day, in nearly every weather condition.

According to Sadoun & Al-Bayari (2007) a GPS enabled device such as a smartphone receives radio wave signals from GPS Satellites that are orbiting the earth (see Figure 10).

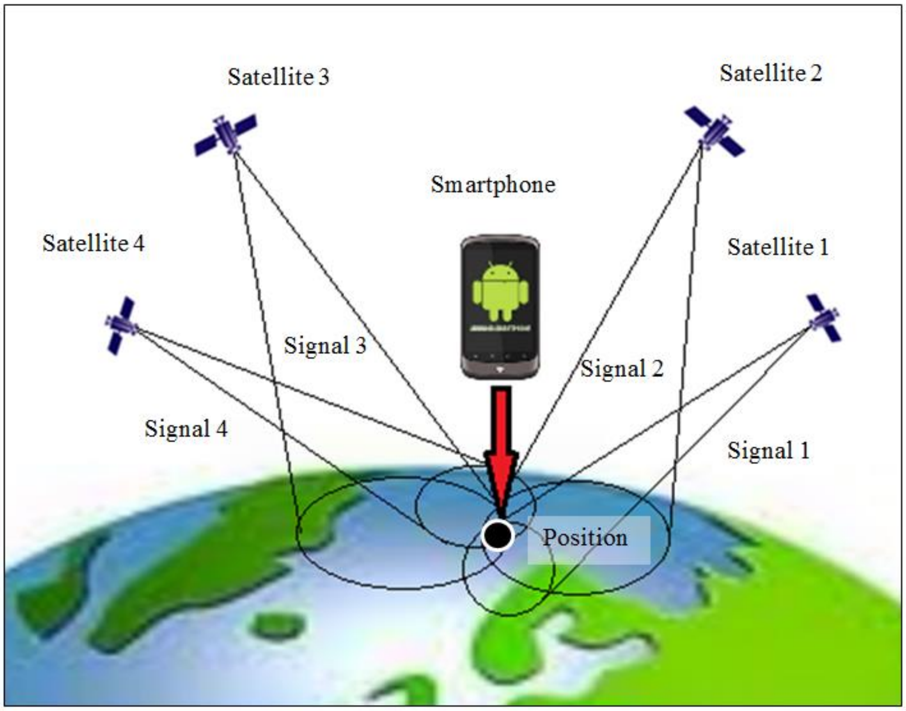


Figure 10: GPS - terminal based method, source Stiasny (2013)

The radio signal contains a time offset and the positional data from each satellite. GPS uses the intersections of spherical planes, based on the radius of the measured distances of the radio signals that travel with light speed from the satellite to the receiver. To determine a two dimensionally position of the smartphone’s location, the receiver needs the signals from at least three satellites. The data of the three satellites are placed in three mathematical equations to calculate the latitude, longitude, and offset time between the clock of the satellite and receiver. For determining a three dimensional position, the altitude of the smartphones location, a fourth signal data stream has to be included in a fourth equation.

Unfortunately, the smartphone device needs to be in direct line of sight contact with the GPS satellites to receive the transmitted radio signals. Buildings, canyon walls, and even thick clouds can block the signal. If the smartphones GPS receiver is used indoors or even very close to a building, no GPS signals can be received. Negative side effect may be high-energy consummation and shorter battery life because of constantly seeking for GPS satellite signals (Zhang, et al., 2012).

2.4.3. Hybrid - AGPS

As has been already explained, GPS needs the radio signals from a minimum of four satellites to calculate the position. This procedure takes about 30–40 seconds until all four data streams are downloaded and the calculation of the position begins. Depending on the signal conditions, e.g. in large cities where buildings with large expanse of glass reflects the signals, the positioning procedure could take several minutes. On the other hand, in the valleys between skyscrapers, there might be no or only a very weak GPS signal. This is where Assisted Global Positioning System (AGPS) comes into play. With the use of an APGS server on the base network of the telecommunication providers, the orbital information of all GPS satellites, the so-called "aided data", are provided and can be downloaded by mobile devices (see Figure 11). With AGPS, the position finding is shortened, and even weak satellite signals can be used. Since the year 2009, every new smartphone device is equipped with an AGPS receiver (Zandbergen & Barbeau, 2011).

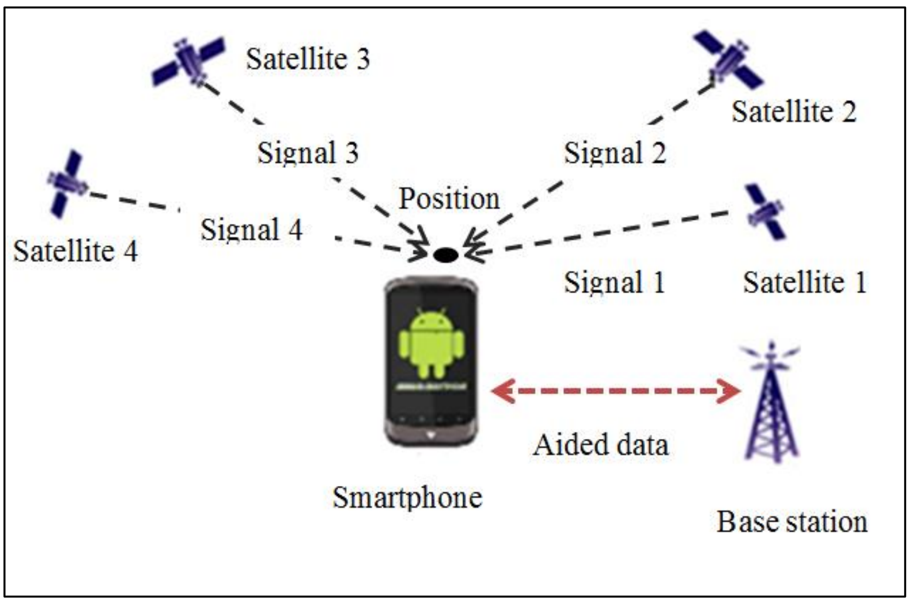


Figure 11: AGPS - Hybrid positioning method, source Stiasny (2013)

Finally, it could be said that network based methods such as the Cell id's using the communication providers base stations or WLAN base stations, provides only a coarse position accuracy within 100 meters. Moreover, WLAN positioning is predominantly used for indoor navigation. GPS, especially the hybrid version AGPS, provides positioning within 10 meters accuracy (Steininger, et al., 2012).

2.5. Location Based Services

According to Steininger, et al. (2012) smartphones and the Internet have revolutionized the communication of people. With smartphones wireless accessibility to the internet, information on events and on places are available on the move. Based on the intersection of New Information and Communication Technologies (NICTS), Internet, and Geographic Information Systems (GIS) the term Location Based Services (LBS) can be defined (see Figure 12).

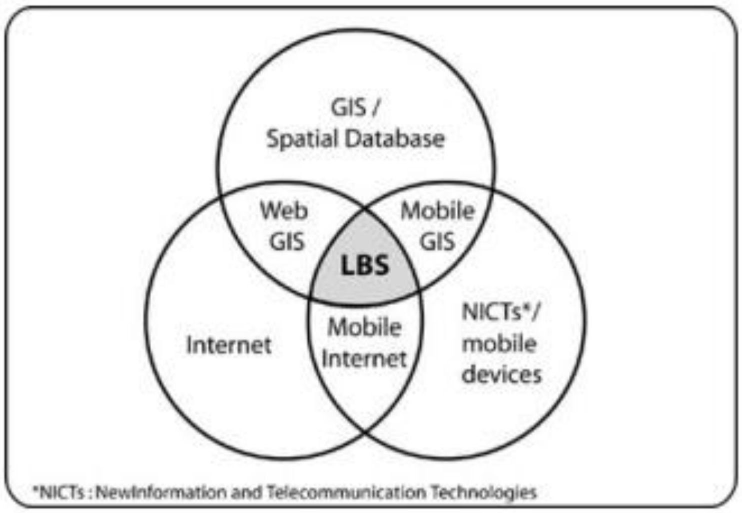


Figure 12: LBS as the intersection of three different technologies, Brimicombe(2002) source: Steininger, et al.(2012)

The work of Kumar et al. (2009) defines LBS as a platform that provides information services based on the current user location that is determined in latitude and longitude coordinates by GPS receivers and supported by web map platforms. Furthermore, the authors also say that in LBS, GIS and wireless communication (WC) is used to provide personalized information on the current location.

Another definition is that *"LBS are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device"* (Virrantaus, et al., 2001).

Location Based Services are developed as limited services for large nonprofessional user groups and give answers in a map context about questions such as (Steininger et al., 2012 cited Virrantaus et al., 2001):

- Where am I?
- What is nearby?
- How can I get there?

Furthermore, Steininger, et al. (2012, cited by Reichenbacher 2004) say that location based services are characterized by a mobile user, which can be a person or a device, and by mobile activities that are locating, navigating, identifying or event checking the information by searching and spatial analysis applying a user interface and visualize information. In Figure 13, the process for answering user related questions based on Heidmann (1999) cartographic information process is shown.

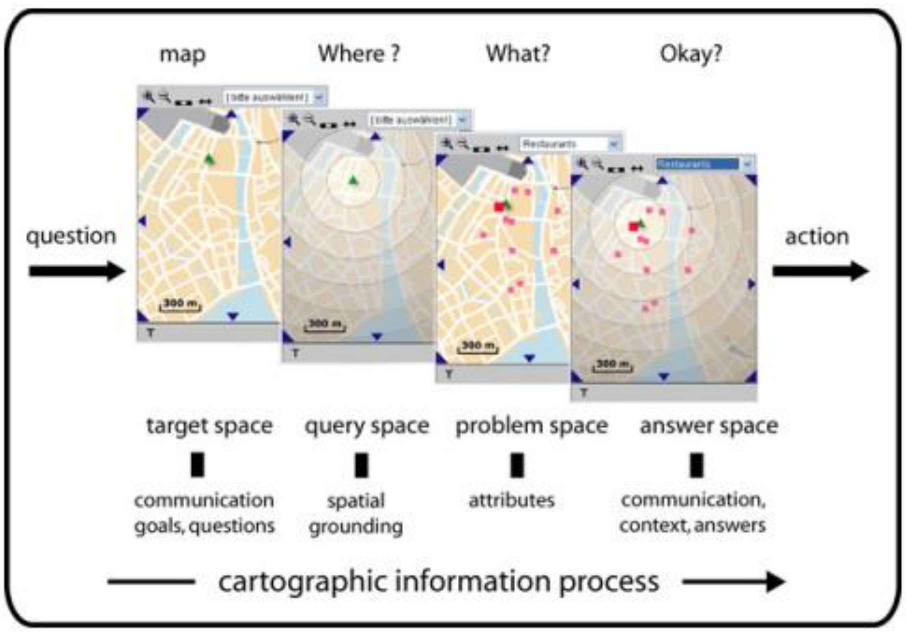


Figure 13: Question and answer model of the cartographic information process by Heidmann (1999), source Steininger et al. (2012)

Moreover, Steininger, et al. (2012)say that there are two different types of location based services in terms of whether user interaction is needed to get information. The first is called pull service, but if information is delivered automatically, it is called push service. A pull LBS can be described similar to a website call with user-entered data in the browser .As result, information would be delivered to the user. Unlike the push service, where information that is not directly requested by the user, for example it could be activated by an event triggered by entering a specific area, information is delivered to the user.

3. Methodology

The following subchapters describe the problem definition with respect to the current situation of the existing convicted sex offender information systems that are accessible via the internet. Possible solution methods are pointed out and the implementation of a solution using current technical standards is described in detail.

3.1. Problem definition

In the United States, several services are in use to manage and monitor the whereabouts and compliance status of registered sex (DSNSOPW 2012, Louisiana State Police 2010). The notification process to the public of a new offender begins within 48 hours. Furthermore, the residences of sex offenders are verified on a 90-day cycle (Tier III)to once a year (Tier I), based on the risk of the offender to the community (DSNSOPW, 2012). Sex offenders move frequently, so the respective law enforcement agency is responsible for monitoring the conduct and compliance status of registered offenders and keeping the addresses database up to date. Two main web platforms provide sex offender information, including OffenderWatch® and the Dru Sjodin National Sex Offender Public Website (DSNSOPW).

OffenderWatch® is the leading sex offender management and community notification tool in the United States. When the results of a search are displayed, it is possible to view details about the offender including a physical description, photo, and map of the offender's residential address (see Figure 14).

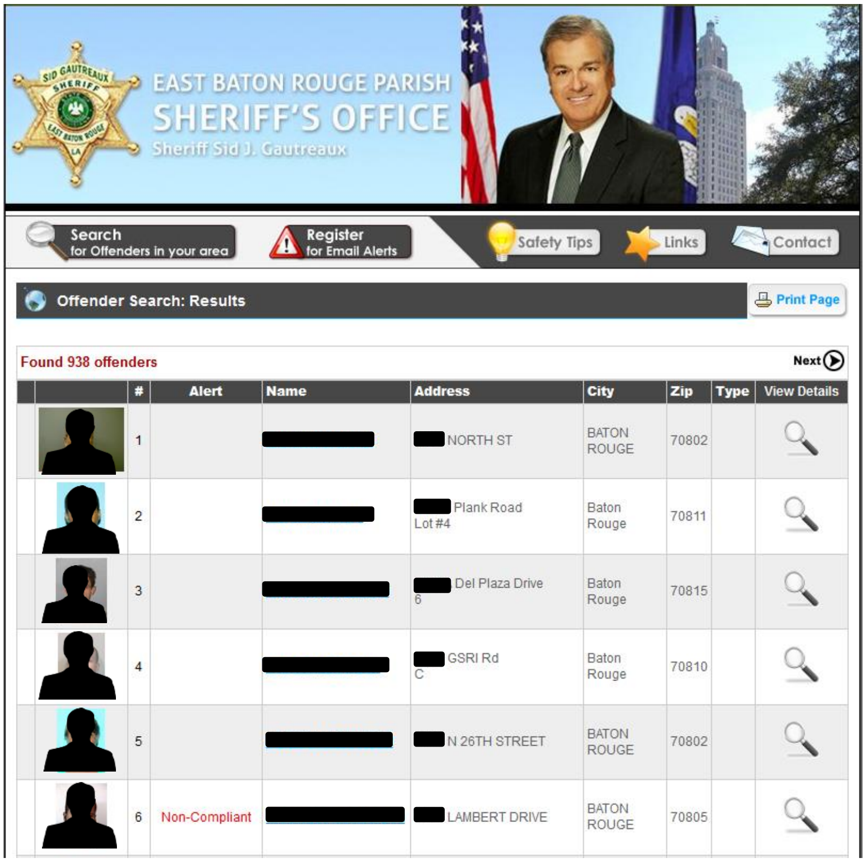


Figure 14: Sex offenders in East Baton Rouge parish using OffenderWatch (2013)

Furthermore, registered users can create maps on the web with the locations of registered offenders within a specified radius of an address that users have entered. If a new offender is registered in the area, OffenderWatch® provides a free email alert system, which informs the user (Figure 15, Watch Systems, LLC, 2012).

Figure 15: Alert email radius from Watch Systems, LLC (2012)

The DSNSOPW is a public service by the U.S. Department of Justice and offers access to participating jurisdictions that publish information about the presence or the location of offenders, who have been convicted of sexually violent offenses against adults and children and certain sexual contact and other crimes against victims who were minors. However, the DSNSOPW does not host the information itself and they do not have the responsibility or control over the content, because that lies in the responsibility of the respective jurisdiction where the sex offenders are registered (see Figure 16).In fact, the DSNSOPW uses a Web service that searches in the different jurisdictions databases for the requested information. This is why the accessed information using this Web service may be not up to date or even inaccurate.

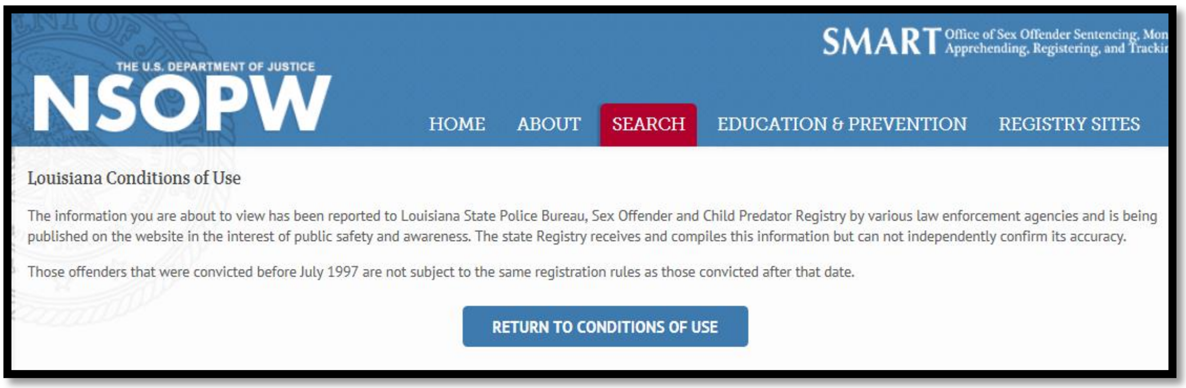


Figure 16: DSNSOPW search information and conditions of use

A sex offender may be registered in more than one jurisdiction. This can happen, when the offenders work, live, attend school, or were convicted in places with different jurisdictions. In addition, each jurisdiction can have different registration requirements and laws. That is why each jurisdiction is responsible for its own sex offender database maintenance and timeliness.

Furthermore, the DSNSOPW does not provide sex offender information to private companies, nor does it offer a Web service or an application-programming interface (API) to use the sex offender information in other applications. On top of that, the OffenderWatch and DSNSOPW web platforms are designed for the use on standard computers via the internet. This allows a better usability with large monitors and input devices such as mouse and keyboard. However, both platforms currently lack a data interface for mobile devices. Even though mobile devices such as smartphones are web enabled, the usability of the web platforms is poor on the small screens compared to the large computer screens. This is the main reason why an adapted client for smartphones should be developed.

3.2. Methods of solutions

Based on the market shares (see Chapter 2.2.1) and the fact that Google still invests a lot of money into the further development of its OS platform, Android is an appropriate smartphone platform for the sex offender visualization prototype.

Most of today's available smartphone devices are limited in respect to having small computing, memory resources, limited energy supplies, and displays, which restricts spatial search calculations and routing operations. Therefore, computationally intensive operations have to be done on a server, which sends the results to the smartphone client. Additionally, access to communication networks such as the broadband UMTS, LTE, or WI-FI for sending and receiving data is necessary. Unfortunately, there is still a lack of broadband access to communication networks especially in many rural areas.

For delivering accurate and timely data, the most appropriate source will be the OffenderWatch web platform (Watch Systems, LLC, 2012) and the National Sex Offender Public Website (DSNSOPW, 2012). Methods to extract the data into a new database, for example MySQL for testing purposes, need to be developed. For setting up an environment that can handle the requests from the Android device, PHP technology is chosen on the server side (Maurice, 2010). Furthermore, a suitable data format for the data transfer from the server to the client, such as extensible markup language (XML), will be used.

For visualizing the spatial information on the Android device, Google Maps will be chosen. Moreover, the mobile device should also have the GPS receiver enabled, in order to provide an accurate user-position. Finally, the user interface of the Android application prototype can only include basic functions, because of its small screen and restricted usability.

Basic functions would be:

- A search function (names and addresses of sex offender);
- A map window, displaying the user's actual position on a map with a scalable search radius for sex offenders;
- Reverse geocoding that shows the address of the user's current position;
- As a result of the search radius point symbols are displayed on the map for representing the locations of the sex offenders;
- The points should be clickable and provide additional information about the sex offender;
- A photo of the sex offender (optional);

The final step includes a live test with an Android smartphone to evaluate functionality and usability. It should be noted that all technologies needed for this project, are open source software and available without extra charge.

3.3. Project area

The project area is defined as the East Baton Rouge Parish (EBRP), which is located in the State of Louisiana, United States of America (see yellow area in Figure 17).

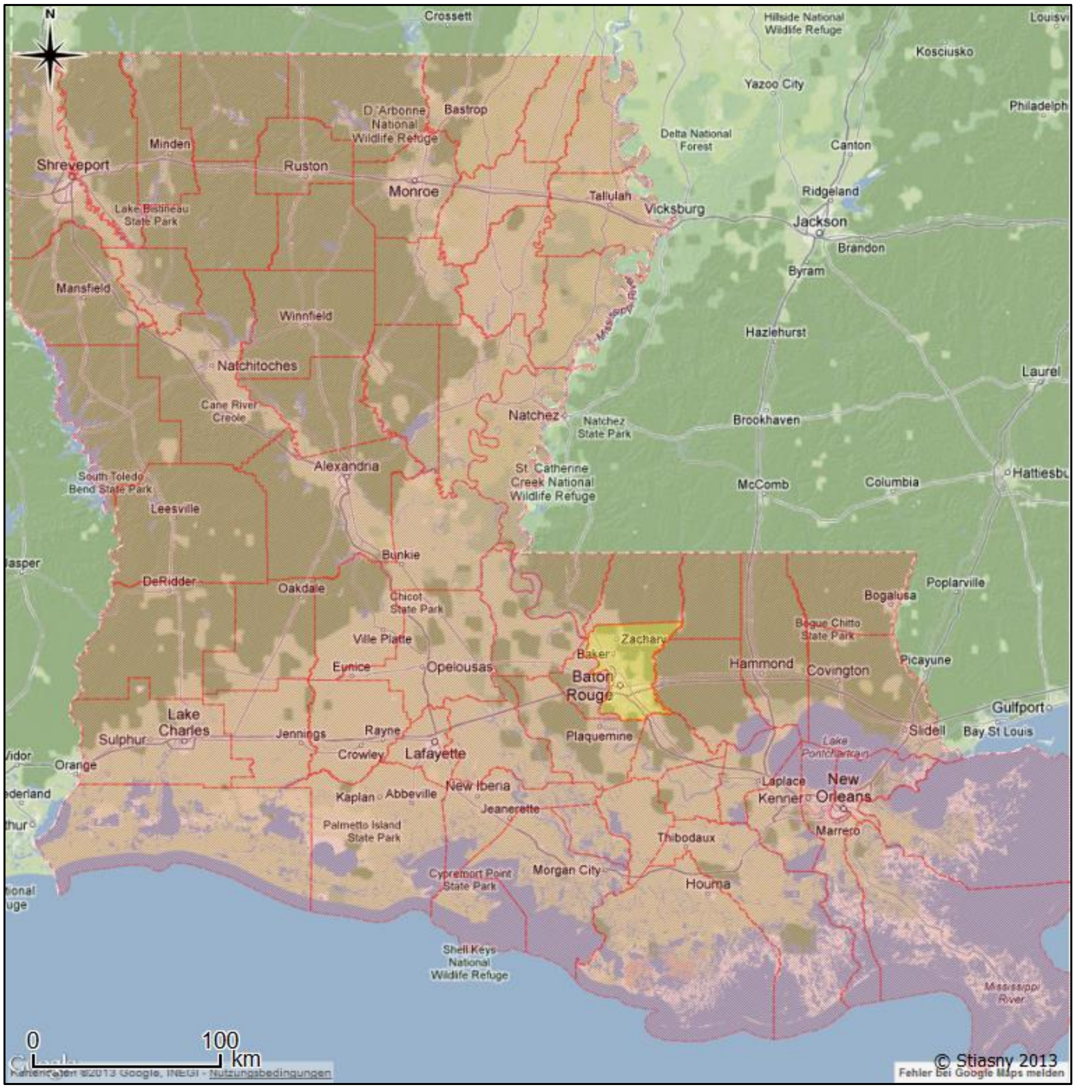


Figure 17: State of Louisiana with parishes on Google maps, source: Stiasny (2013)

EBRP is the area east of the Mississippi river and includes the city of Baton Rouge, the capital of the State of Louisiana. The parish covers an area of approximately 1220 km² or 471 mi² and is divided into 24 Zip Code districts, which includes sub Zip Codes (see Table 7, John Coryat - USNaviguide, 2009).

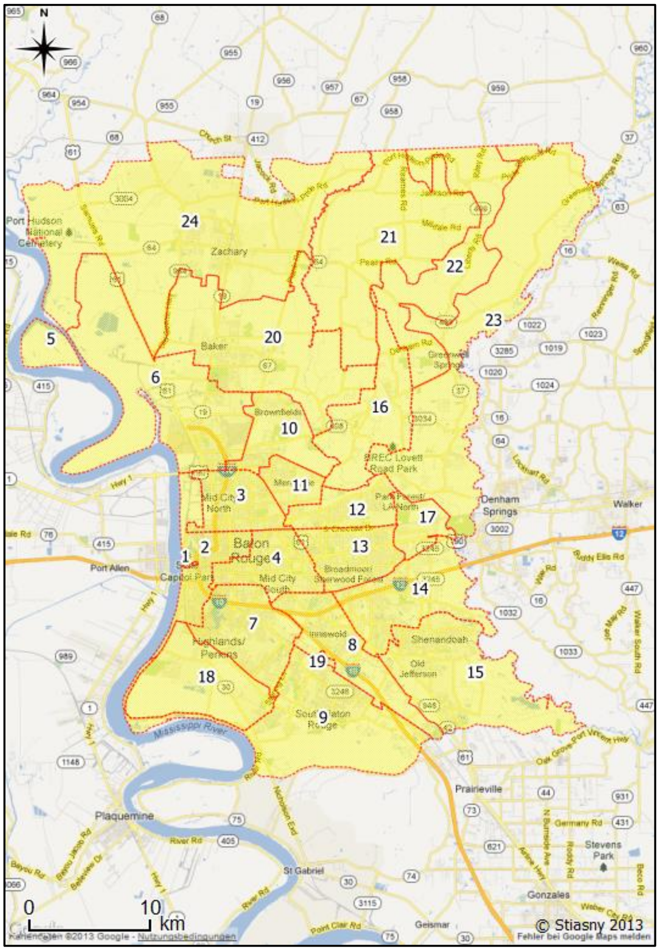


Figure 18: East Baton Rouge parish with ZIP code districts, source: Stiasny (2013)

Table 7: East Baton Rouge Parish Zip code districts

Nr	Zip Codes	Name
1	70801	Baton Rouge
2	70802, 70803, 70821, 70833	Baton Rouge
3	70805	Mid City North
4	70806, 70804, 70831, 70893, 70894, 70892	Mid City South
5	70807	Scotlandville
6	70807, 70813, 70874	Scotlandville
7	70808, 70898	Highlands/Perkins
8	70809, 70836	Inniswold
9	70810, 70884	South Baton Rouge
10	70811	Brownfields
11	70812	Merrydale
12	70814	Monticiello
13	70815, 70895	Broadmoor/Sherwood Forest
14	70816, 70879	Forest Park
15	70817	Shenandoah
16	70818, 70837, 70896	Central
17	70819	Baton Rouge
18	70820	Baton Rouge
19	70836	South Baton Rouge
20	70714	Baker
21	70791	Zachary
22	70770	Brownsfield
23	70739	Greenwell Springs
24	70791	Zachary

Based on the United States Census Bureau (2013) the East Baton Rouge area had 444,526 inhabitants in the year 2012. The population can be broken down as follows: 50% whites (Caucasian), 45.5% Afro Americans, 0.3% American Indian and Alaska natives, and 3% Asian persons. In 2011, there were 187,711 housing units with 161,150 households in the EBRP. 29.6% of the housing units were houses with multi-unit structures.

3.4. Data

As has already been mentioned previously, the whereabouts of convicted sex offenders is stored in different databases all over the United States and is freely accessible via web-based applications. Sheriffs from the parishes, where the sex offenders were convicted or are residing, are responsible to create or update the sex offender record datasets in the databases. In the EBRP sex offenders have to register with the responsible law enforcement agencies of the parish and provide the following information (Louisiana State Police, 2010):

- Name and any aliases used by the offender
- Physical address or addresses of residence
- Name and physical address of place of employment
- Name and physical address of the school in which he/she is a student
- A current photograph
- Fingerprints, palm prints, and a DNA sample
- Physical description (sex, race, hair, eye color, height, age, weight, scars, tattoos, etc.)
- Telephone numbers
- Every email address, online screen name, or other online identity
- Every vehicle registered to or operated by the offender, including the license plate number
- Social security number and date of birth
- Temporary lodging information regarding any place where the offender plans to stay for seven or more days.
- Travel and immigration documents, including but not limited to passports and documents establishing immigration status.

The EBRP Sherriff’s Office had 908 convicted sex offenders registered in their jurisdiction ZIP Code area (see Table 8) in April 2013. In 901 cases, the locations of the convicted sex offenders were mappable for the police. That means that 7 persons in the East Baton Rouge area were living in places that had no physical address, e.g. they were homeless or lived in mobile homes. . Furthermore, those 908 sex offender recordsets contained 60 recordsets with sex offenders already deceased. The remaining recordsets are the databasis for the Android prototype application.

Table 8: Sex offender race and sex distribution

Race	**Sex**		**Quantity**
	Male	Female	
Afro American	604	15	619
Asian	5	0	5
Caucasian (White)	205	12	217
Hispanic	5	0	5
Other	2	0	2
Deceased			-60
Total			**908**

3.5. Implementation

This implementation describes the architecture and the technologies that are used for the Android based LBS. Referring to Heidmann's question and answer model (1999), see Chapter 2.5. In Location Based Services, elements can be defined to describe the LBS connectivity to provide geospatial information to the user. Figure 19 shows the main elements such as the web map service (target space), a positioning system (query space – where?), a webserver in combination with a database to query spatial and non-spatial data (problem space – what?) and a mobile smartphone client (answer space) to receive user input and visualize the queried content.

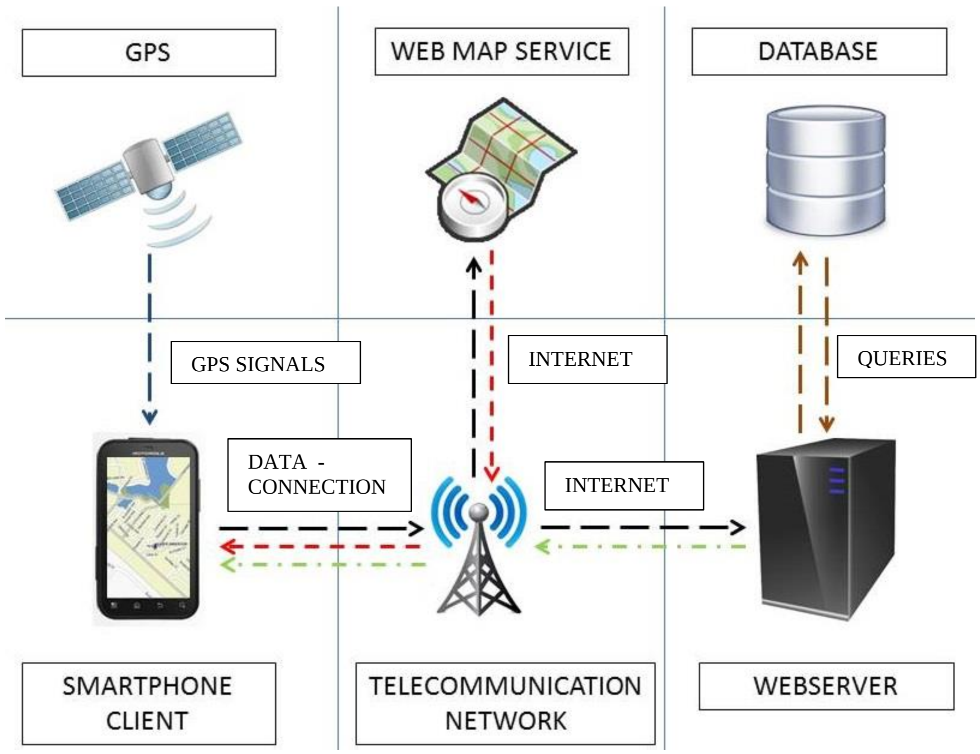


Figure 19: System architecture of the Android LBS, source Stiasny (2013)

3.5.1. GPS

The positioning of the smartphone's location will mostly be done via the internal AGPS receiver. At least four GPS satellite signals have to be received to calculate the location within ten meters accuracy in WGS84 latitude and longitude coordinates. As has already been mentioned in Chapter 2.4.3, the AGPS receiver works in combination with the WWAN data connection of the communication provider to shorten the time for determining the position. In case of receiving poor or no GPS signals, e.g. in the valleys of skyscrapers, the Android smartphone mobile client should try to get the approximate location via network based positioning. More details about the positioning methods can be found in the smartphone mobile client in Section 3.5.3.

3.5.2. WMS

The web mapping service (WMS) is the part of the LBS that renders map tiles, visualizes the queried point data on the map tiles as markers, and provides geocoding. There exist several WMSs, such as Google Maps, Bing Maps, Open Street Map, or others. Google Maps and Bing Maps are the two main services and in terms of functionality, Google Maps and Bing Maps are nearly equal. The easiest way to provide map functionalities on Android smartphones is Google Maps, because first, Android is a Google product and second, there exists a very well documented application programming interface website powered by Google with several tutorials and code examples.

3.5.2.1. Google maps

For this implementation, Google Maps API V2 is used. With the Google Maps API V2 Google provides Android devices with full access to the Google maps functions. Furthermore, the Google maps API allows to specify which type of positioning is preferred, namely terminal or network based methods. The zooming level ranges from 17 to zero (high to low). Different map types are accessible, i.e. street, traffic, satellite, hybrid, and others .The user can add layers for custom markers or polygons. The Google maps API V2 requires a registration at the Google maps API website to obtain a key that allows the Android application to view maps. However, currently Google limits the map requests with 50,000 per day. In terms of geocoding, Google Maps API V3 includes forward and reverse methods (Google Developers, 2013).

3.5.2.2. Geocoding

Forward geocoding is a location utility service that transforms a postal address, postal code, or place name into a geographic position with WGS84 latitude and longitude coordinates. Reverse geocoding is a process that transfers WGS84 coordinates into a location related postal address, see Figure 20 (Android Developers, 2013).

Figure 20: Forward geocoding and reverse geocoding

3.5.1. Webserver

An Apache webserver in combination with PHP technology is responsible for querying the database with the requests from the smartphone mobile client. Once the PHP interface receives a Hypertext Transfer Protocol (HTTP) request from the mobile client, parameters, such as the WGS84 latitude, longitude and the search radius are passed and stored in PHP variables. With those parameters spatial queries on the database are started.

```
$userLat = $_GET["user_lat"];
$userLon = $_GET["user_lon"];
$miles = $_GET[“user_radius”];
```

Furthermore, the PHP interface accepts user queries about offender data stored in the databases. The PHP interface triggers a query on the database and receives a result set that is stored in XML and HTML objects, which are provided as a response to the mobile client’s request.

3.5.2. Database

When it comes to spatial queries, mostly PostgreSQL databases are used because they are free and open source products with a good performance for complex spatial queries. Since only point datasets and distance calculations between point locations are needed for this implementation, a MySQL database is the right choice because it can handle simple spatial queries with a greater performance than a PostgreSQL database can do (Lee, 2012).

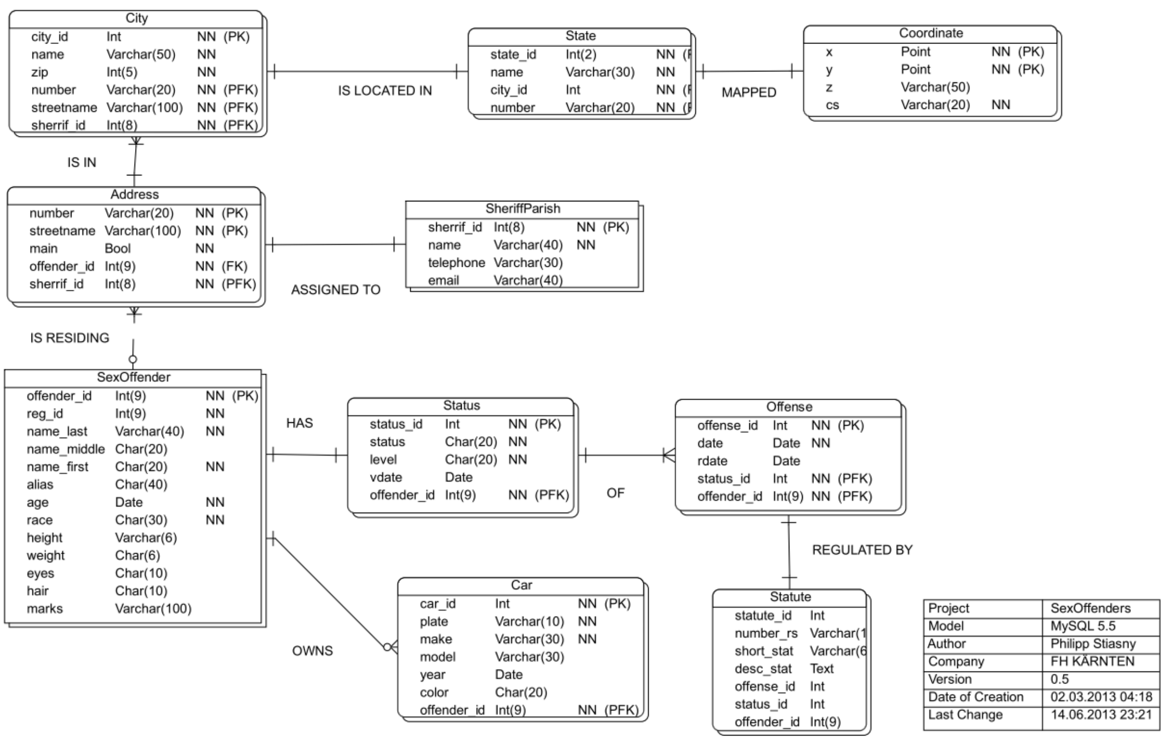


Figure 21: Database model

3.5.2.1. MySQL

The convicted sex offender data from the OffenderWatch database need to be manually populated into the MySQL database, based on the developed database model. Each convicted sex offender location is a point geometry data type that has latitude and longitude coordinates. With reference to MySQL AB (2008) a spatial index over those point geometries is created and stored in the database. With the coordinate pairs of the offender locations, the known user's location, and the search radius, a spatial query is prepared on the PHP side and triggered in the database. The following lines of PHP code illustrate the implementation of the MySQL query that return as result set the coordinates of convicted sex offenders in a defined radius of the user's location.

```
$point1 = $userLon + $miles / ( 111.1 / cos($userLat));
$poin2 = $userLat + $miles / 111.1;
$point3 = $userLat - $miles / ( 111.1 / cos($userLon));
$point4 = $UserLon - $miles / 111.1;


$query = "SELECT * FROM geom WHERE
MBRContains(GeomFromText('LineString(".$point1." ".$point2.",
".$point3." ".$point4.")'), latlng)"
```

3.5.3. Smartphone mobile client

The Android smartphone mobile client is a pull-based implementation. In other words, if the user triggers an event the mobile client has implemented activities for determining the users actual position, visualizes the locations of sex offenders in a user defined radius around the user's location, and allows the user to search for offenders in the database through query activities.

One of the mobile client's activities instantiates a self-implemented Java Class called GPS that implements the LocationManager. The LocationManager is one of Android's modules to handle the communication with the smartphones positioning sensors. It exposes a number of methods to receive location updates, for example with specified time minimum and distance intervals at which the positioning sensors are triggered for location updates. Sensors, such as the smartphones internal AGPS receiver determines the user's exact position via WGS84 coordinates.

Once the exact location is known, another activity prepares the WGS84 coordinates plus a user defined search radius (one, two, three miles or all three distances) for the transmission to the webserver to query the locations of convicted sex offenders near the user’s actual position. By using the WWAN connection of the telecommunication provider, an internet connection is established to access the webserver via the HTTP protocol.

With the webservers response, an activity generates markers with the latitude and longitude positions of the convicted sex offender’s locations on Google map. The user’s actual position is added and centered on the map and a red circle with the chosen radius is drawn around the location. All offender location markers should be inside of the red circle or sometimes lie even on the edge of it.

3.5.4. GPS Class

The following lines of JAVA code illustrate the implementation of the GPS and the network-positioning providers in the GPS class of the mobile client. Both implementations contain the parameters minimum time (MIN_TIME_BW_UPDATES) and minimum distance (MIN_DISTANCE_CHANGE_FOR_UPDATES). Minimum time is a parameter that sets a static location update interval in milliseconds. The minimum time parameter is important for conserving battery life, because each location update requires power for GPS, WIFI, Cell or other wireless providers. For this implementation, a minimum time value of two minutes (1000 * 60 * 2) is set. The minimum distance parameter is used to control the frequency of location updates and is set to 10 meters (The Android Open Source Project, 2013; Android Developers, 2013).

3.5.4.1. GPS provider

```
if(gpsProvider)
{
	if(location == null)
		locationManager.requestLocationUpdates(LocationManager.GPS_PROVIDE
		R, MIN_TIME_BW_UPDATES, MIN_DISTANCE_CHANGE_FOR_UPDATES, this);
	if(locationManager != null)
	{
		location =
		locationManager.getLastKnownLocation(LocationManager.GPS_PROVIDER)
		;
		if(location !=null)
		{
			latitude = location.getLatitude();
			longitude = location.getLongitude();
		}
	}
}
```

3.5.4.2. Network provider

```
if(networkProvider)
{
      locationManager.requestLocationUpdates(LocationManager.NETWORK_PROVIDER
      , MIN_TIME_BW_UPDATES, MIN_DISTANCE_CHANGE_FOR_UPDATES, this);
      if(locationManager != null)
      {
            location =
            locationManager.getLastKnownLocation(LocationManager.NETWORK_PROVI
            DER);
            if(location != null)
            {
                  latitude = location.getLatitude();
                  longitude = location.getLongitude();
            }
      }
```

3.5.4.3. Geocoding

The latitude and longitude coordinates of the LocationManager module are received in decimal numbers. This is useful for calculating locations and distances to other locations but not when it comes to providing the user's information about his/her actual location. Therefore, it is much more suitable to view the user's position as a postal address. The Google Maps API allows reverse geocoding from WGS84 coordinates to the approximate postal address with the Geocoder module. The following lines of JAVA code illustrate the implementation of the Geocoder module (The Android Open Source Project, 2013).

```
Geocodergeocoder = newGeocoder(mContext, Locale.getDefault());

                  Location loc = params[0];
                  List<Address> addresses = null;
                  try
                  {
                        addresses =
                        geocoder.getFromLocation(loc.getLatitude(),
                        loc.getLongitude(), 1);
                  }
                  ……………………………………………………………..

                  if(addresses != null&&addresses.size() > 0)
                  {
                        Address address = addresses.get(0);
                  //Format addresses, city and country name

                        String addressText = String.format("%s, %s, %s",
                        address.getMaxAddressLineIndex() > 0 ?
                        address.getAddressLine(0)    :"",
                        address.getLocality(), address.getCountryName());
                        ……………………………………………………………
```

3.5.5. Data format

In order to transmit the data in a uniform format, the result set of the database query is stored in extensible markup language (XML) objects by the PHP interface. XML is a human readable encoding of a document that consists of one or more elements. The XML definition states that there is exactly one element, the root element, or document element, with none of it appearing in the content of any other element. Furthermore, the XML standard is defined by start-tags and end-tags that mark the beginning and the end of an element. If the start-tag is in the content of another element, the end-tag is in the content of the same element. Each XML element consists of a type that can be identified by a name and may have a set of attribute specifications. Each attribute consists of a name and a value (W3C, 2008). The following XML tree shows the schematic construction of the XML object that is generated by the result set of a spatial query by the PHP interface to provide the requested information to the mobile client.

3.5.5.1. XML document


```xml
<?xml version="1.0" encoding="UTF-8"?>
<offenders>
	<offender>
		<id>000000001</id>
		<regId>000000815</regId>
		<firstName>First</firstName>
		<lastName>Last</lastName>
		<middleName>Middle</middleName>
		<alias>Cotton Eye Joe</alias>
		<level>Tier 1</level>
		<status>Active</status>
		<age>45</age>
		<race>Afro American</race>
		<height>5'06"</height>
		<weight>139lbs</weight>
		<eyes>Brown</eyes>
		<hair>Black</hair>
		<imageUrl>http://serverUrl/imagecontainer/number.jpg</imageUrl>
		<marks>
			<mark>Tattoo right arm</mark>
		</marks>
		<addresses>
			<address>
				<main>true</main>
				<streetNumber>1234</streetNumber>
				<streetName>StreetName</streetName>
				<cityName>Baton Rouge</cityName>
				<stateName>LA</stateName>
				<zipCode>70802</zipCode>
				<coordinates>
					<latitude>30.45319</latitude>
					<longitude>-91.169296</longitude>
					<geoPoint/>
				</coordinates>
			</address>
		</addresses>
		<offenses>
			<offense>
				<statute>14:89.1</statute>
				<offenseName>Aggravated Crime Against Nature</offenseName>
				<date>10/07/2010</date>
				<details>none</details>
			</offense>
			<offense>
				<statute>14:81</statute>
				<offenseName>Indecent Behavior with Juveniles</offenseName>
				<date>07/26/1985</date>
				<details>Juvenile Victim</details>
				</offense>
		</offenses>
	</offender>
</offenders>
```

3.6. Summary

In the first subchapter of this chapter, the problem definition of this Bachelor Thesis is provided. In the second subchapter, solutions to this problem are provided. The project area, which is the EBRP, is briefly described and a short introduction to the used convicted sex offender data is given. The final subchapter gives an idea of the implementation of the LBS and is modularized. A short overview of each module is given together with selected code sections.

4. Results and Interpretation

In this chapter, the results of this work are presented and discussed. It was the goal of this work to develop a visualization method for the convicted sex offender locations on Android smartphones. As described in Chapter 3.5 (Implementation), some of the developed modules are required as interfaces to other modules. Due to this configuration, primarily the results of the Android mobile client are described. Since every module of the whole LBS implementation is based on each other and is a correct function of the mobile client, which is the top level of access, a well-implemented system has been developed.

4.1. Android mobile client

For each of the defined LBS modules (GPS, WMS, Webserver, Database and Android Mobile Client) tests were made to verify the correct interaction of their interfaces. Finally, a field test of the LBS was conducted in May 2013. A test under live conditions is necessary in order to verify the accuracy and the functionality of the whole LBS. From the entire EBRP test area, a location one mile west of the airport was selected. The reason for this choice is a cluster of offender locations in that area. Finally, a location in a residential area close to Scotland Avenue and near the interstate 110 was chosen to perform the test.

As test device, a Motorola Razr i Android smartphone with a 4.3” display, AGPS sensor, and internet access was used. After the internet connection was established, the Android mobile client successfully started and the GPS class triggered the LocationManager in order to determine the position of the device. Once the location was known, a toast message, which is a pop up message window, showed the latitude and longitude coordinates on the screen and Google maps started with the current location centered on the map. After selecting the search radius with one mile, the show offender button of the mobile client was activated. Over the smartphone’s internet connection, the offender query with a one-mile radius and the retrieved location was sent to the webserver. In the background, the request had been processed by the webserver’s interface to the database and returned the result as an XML object to the mobile client. The result stored in the XML object was interpreted by the client and visualized on the map (see Figure 22).

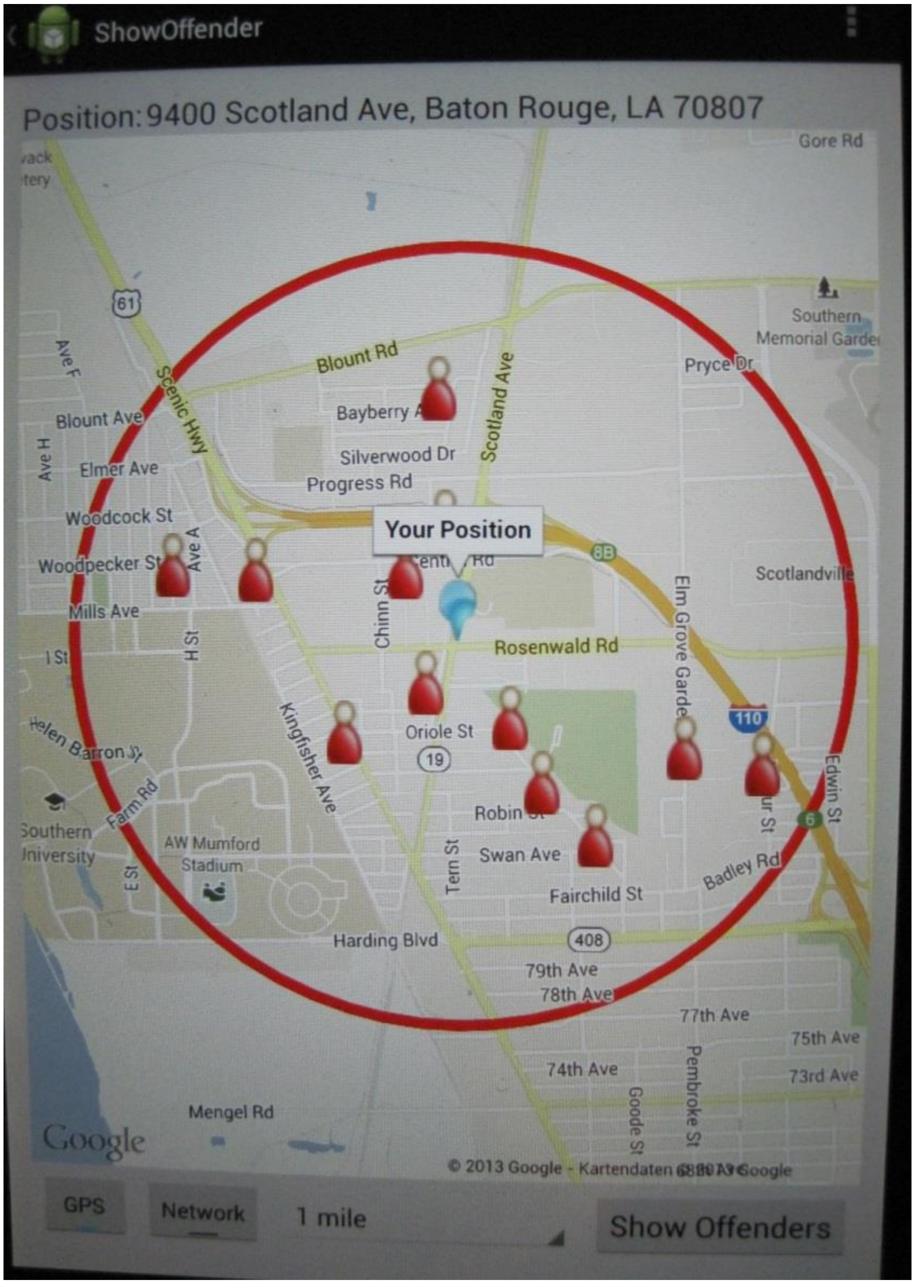


Figure 22: Result of the Android mobile client outdoor field test with a 1-mile radius on an Android Razr i smartphone

The user's position is drawn as a blue pin and the one-mile search radius is drawn as a red circle around the user's position. Inside the one-mile radius of this position, twelve convicted sex offender locations were found and drawn as red markers on the Google map. Each of the red markers is clickable and shows the name and some basic information, such as the race, hair color, height, age, address, and the status of the offender. In Figure 22, the information about the convicted sex offenders is kept anonymous and therefore no information, which is provided by the clickable markers, is shown.

4.1.1. Geocoding

The amount of detail in the description of a reverse geocoded location may vary from a full street address of the closest building to only a city name or postal code. In the geocoding process, a query of the Geocoder class returns an array of addresses from the Google Maps API. If no address is found near a position, an empty list is returned to the Geocoder. The results in the array are more a best guess and not guaranteed to be a correct result. In the live test, the address was almost correctly determined in the reverse geocoding process. Merely the exact number of the location, where I was standing could not be exactly determined. Specifically, I was standing on “9422 Scotland Ave” and the address determined by the system was “9400 Scotland Ave, Baton Rouge, LA 70807”.

4.2. Database queries

In addition to the visualization of the convicted sex offender locations, the mobile client allows database queries of offender data. This is an extra feature, which allows the user to search for names or addresses. Once the user request is processed on the webserver, the result set is stored in a HTML document that the webserver provides via HTTP response to the mobile client. The HTML document contains a list of names and addresses with information about the related convicted sex offender results. On the mobile client side, a webview activity interprets the HTML document and visualizes the result on the display. As has been already mentioned in the previous chapter, the information about the convicted sex offenders is kept anonymous and therefore only a query result set with offender dummy data is shown (Figure 23).

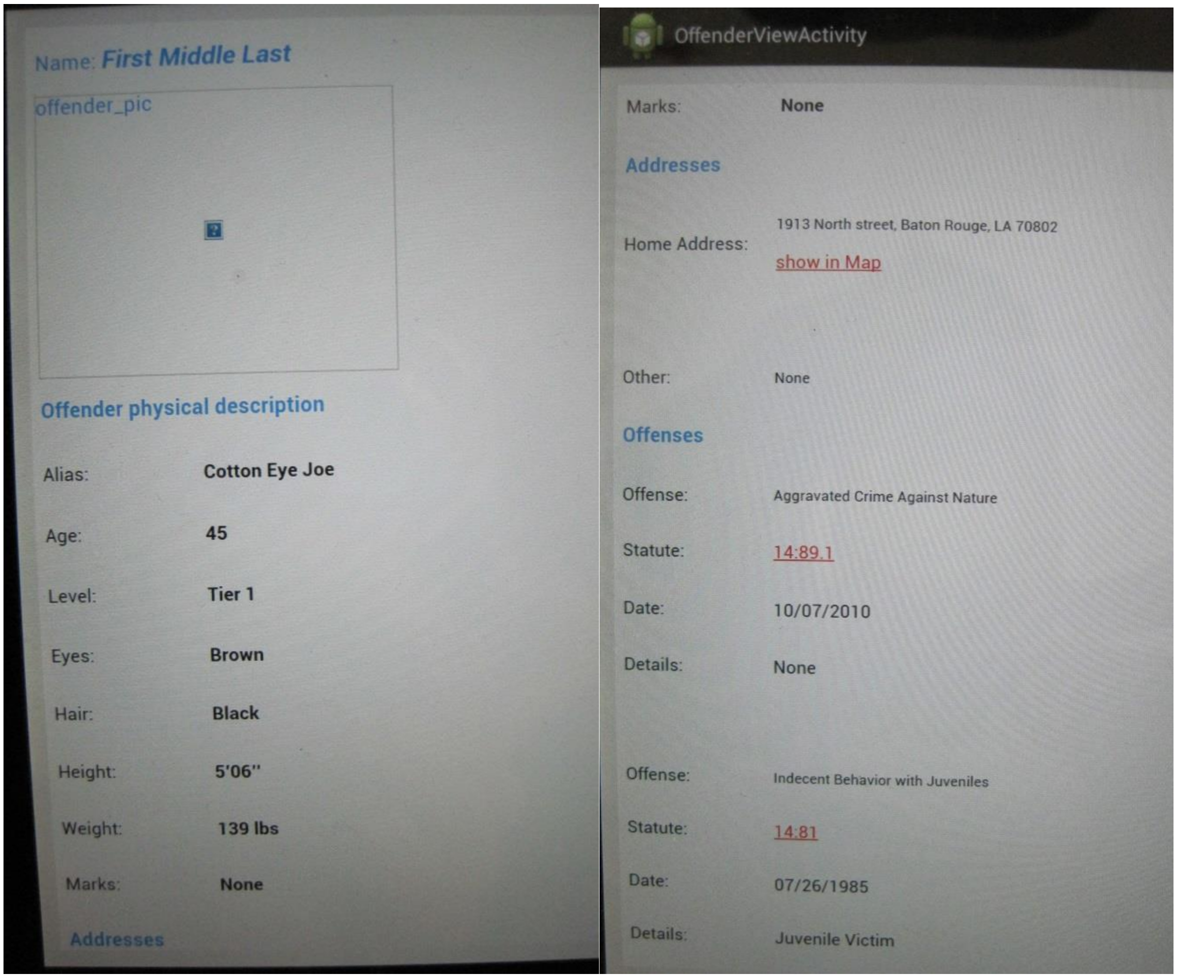


Figure 23: Result set of offender query from the database, showing dummy data on Android Razr i smartphone

5. Discussion

The main content of this Bachelor Thesis was to develop a visualization method for the location of convicted sex offenders in EBRP. In this thesis a prototype model on the basis of Heidmann's (1999) question and answer model of the cartographic information process was developed. All expected results, the development of an Android based prototype on the client side, a manually populated test database with data of convicted sex offender's from EBRP, a web interface for triggering geospatial queries on the database that were defined in Chapter 1.4, have been met. Finally, the developed prototype has been evaluated in a live field-test. The live field prototype test showed that the LBS basic functionalities worked successfully and that the accuracy of the geocoding was sufficiently high.

The Android mobile client has to be optimized for transferring as little data as possible via the internet connection. In other words, data caching needs to be implemented in the mobile prototype to eliminate redundant or repetitive lookups on the webserver. Referring to Reto (2012) another important point is to stop all data transfers and GPS location updates when the map activity is not visible to the foreground of the user's interface. This extends the smartphone's battery life and reduces the levels of the costs of the data transfers over the mobile network.

6. Conclusions and future work

6.1. Conclusions

In the United States of America each year, the number of smartphone users is increasing. The Google owned Android smartphone platform offers the user several free of charge services such as Google Maps. The live field prototype test developed in this Bachelor Thesis showed that the LBS basic functionalities worked successfully and the accuracy of the geocoding was good. The result of the reverse geocoding process of a position is sufficient, but could be better in terms of finding the correct address number. However, this particular problem is with Google's Geocoder and might be improved in the future.

6.2. Future perspectives

Smartphones are constantly evolving and always getting a more and more powerful hardware that enables new features and functions. A major problem is currently the smartphones power supply with its battery. The huge high-resolution displays, antennas, and sensors are very power consummating and in the case, all wireless features, such as network synchronization over the internet, WIFI, or Bluetooth functions are activated, the battery range is rather short . In the near future, when the power supply problems are solved, it might be possible to access Google Map services that automatically detect the user's location and check the surrounding, to warn the user, if there is a potential danger or risk, such as the residence of a sex offender.

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8. List of Figures

9. List of Tables