IoT based Anti-Crime Platform using MicroGPS chip

Supervisor
Dr. C Nyirenda

Developer
Mr. S Mbiza

Co-Supervisor
Mr. A Henney

ABSTRACT

The purpose of this project is to design, implement and test an IoT based Anti-Crime platform using unobtrusive MicroGPS chips. This project is chosen due to the high crime rate present in South Africa. This project will help in fighting crime and provide more security to property. The project consists of four parts. The first part is requirement analysis, where I define the requirements and break them to simple form. The second part is design and prototype, where a platform is designed and a prototype is produced. The third part is implementation, where code is written and a working product is produced. The fourth part is testing, this is where the product is tested and bugs are fixed if any. To use the application, one is required to have a PC or laptop. The product will be implemented in Java and an OpenCPU platform, which satisfies the entire MicroGPS chip requirements will be used.

1 INTRODUCTION

1.1 Background

One of the most difficult challenges faced by South Africa is crime [1]. Crime rates of this country are very high and everyone is affected [1].The levels of recorded crime in this country have been increasing since the mid-1980 [2]. "A comparison of crime rates shows that Johannesburg has the highest level of crime followed by Pretoria, Cape Town and Durban" [2]. The emigration of South African professional maybe because they are trying to escape high crime environment [1]. Young people especially those residing in townships are more likely to be the victims of crime [2]. Wealthy suburban residents are more likely to be victims of property crimes [2]. In South Africa crime rates are very high. Statistics show that are mugged almost every day, they lose their personal belongings such as smartphones, laptops, backpacks, handbags and there is no way of locating these items. Imagine on your way to or from work, you get mugged and your bag which contains your belongings is stolen. In this moment you lose everything inside your bag and there is no way of getting it back. South Africans face this problem on daily basis. With advances in technology GPS chips are becoming smaller in size and this represents an opportunity to deploy them in small property such as backpacks, laptops and other small belongings. This will help to fight crime in South Africa as it will be possible to track stolen property.

1.2 Problem Statement

GPS chips are limited to medium size property such as cars due to their size and power. There is lack of tools for tracking small property such as backpacks and laptops. To get a GPS with high precision positioning requires advanced tools meaning the costs are high [3]. There is a need for a low cost MicroGPS tracking system.

1.3 Objectives

The aim of this project is to use these small GPS chips and develop an Internet of Things platform that will keep track of personal property. The small GPS chip will be mounted on the property in a manner that does not necessary attract attention. The objectives of the project is to design, implement and test our anti-crime platform. The GPS chip must have the following properties, small in size, programmability, bidirectional communication, low cost and low power consumption.

1.4 Significance of the Project

The applications of this project includes helping crime units to locate stolen objects efficiently and /or having a personal tracker to locate misplaced property.

2 LITERATURE REVIEW

2.1 Overview of GPS

"The Global Positioning System (GPS)is a satellite-based navigation and a surveying system for determination of precise position and time, using radio signals from the satellites, in real-time or in post-processing mode" [4].

This is how GPS works, first it is divided into three segments: the user segment, the space segment and the control segment [4]. The space segment, consists of 24 satellites orbiting the earth and their setup makes sure that at least four satellites are in view from every point on the earth at any time for positioning (3-D positioning) and navigation purposes [4]. Control segment, the control segment consists of a master control station (MCS), monitor stations (MSs) and an up load station (ULS) [4]. MSs consists of receivers and computers that are used to track satellites and collect ranging data from navigation signals [4]. This data is then transferred to the MCS for predicting satellites position, velocity and clock drift [4]. The ULS is used to load navigation messages into satellite memory [4]. The user segment contains user equipment such as a receiver, antenna, a data-processor with software and a display unit [4]. The GPS receiver computes the range and other data using navigational signals from at least four satellites for 3-D positioning and the position is displayed in coordinates, UTM, grid or other types of coordinates [4]. Errors and delays such as delays due to ionospheric refractions which are catered for by the processing software [4].

When it comes to receivers, there many types depending on your specific need [4]. These types range from high precision Rouge receiver to the hand-held navigation receiver [4].

2.2 GPS tracking systems

There are reports, articles and Journals about GPS tracking system. For instance the GPS vehicle tracking system, it was a project about "automotive localization system using GPS and GSM-SMS services" [5]. Basically they developed a tracking system that will send the position of the vehicle to the owner via a short message [5]. Their tracking system was made up of a GPS receiver, microcontroller and a GSM Modem [5]. Their system presented a low cost solution for car tracking and have many applications which includes car theft situations, monitoring adolescent drivers and others [5].

Another project used GPS to help people from getting lost in unfamiliar places, to monitor children, to track business vehicles and others [6]. The aim of the project was to build a GPS tracing device and their system consisted of a GPS module that is used to collect data from the satellite and triangulate position [6].

2.3 MicroGPS Tracking Systems

For micro-GPS there are articles and reports about projects that involved the use of a micro-GPS. A project was done to design and implement a GPS based personal tracking system [7]. The main objective of the project was to create a GPS based personal tracking system that is able to determine the position of a person or any other object that are valuable and this system uses a GPS to get the exact location of the person or the object [7]. The platform consisted of a GPS receiver and a GSM modem and they use an OpenCPU platform to eliminate the need of a separate microcontroller [7]. The size of the personal tracker was 1.5 x 3.75 inches with an accuracy error (exact position of the target) of less than 30m (CEP) [7].

A conference paper demonstrating the LEA-6T GPS receiver was published. "LEA-6T GPS receiver is an integrated navigational GPS module created by uBlox" [8]. This GPS differs from other GPS due to the fact that it does not only send position but it also sends raw data like pseudo range, carrier phase and Doppler [8]. The aim of the study was to "examine the usefulness of these findings for precise positioning, which would allow to use the test receiver in satellite geodesy" [8]. The size of the LEA-6T GPS receiver is 0.669291x 0.866142x 0.0944882 inches and it is low cost [8]. Tests were carried out and the results obtained showed that the performance of LEA-6T receiver was acceptable [8].

Authors [9] used a micro-GPS receivers to track small-bodied mammals [9]. The aim of the study was to compare the performance of two micro-GPS receivers (traditional and snapshot) on pygmy rabbit and furthermore find out how GPS errors might affect "fine-scale assessments of space use and habitat selection" [9]. For this project they used the traditional and snapshot micro-GPS receiver weighing less than 20grams [9]. They were interested in a fix success rate (FSR) and location error (LE) and their final results suggested that "micro-GPS receivers are capable of addressing questions about space use and resource selection by small mammals, but that additional techniques might be needed to identify use of habitat structures (e.g., burrows, tree cavities, rock crevices) that could affect micro-GPS performance and bias study results" [9].

There is a research article [10] for monitoring wild turkey movements and choice of habitat [10]. For this research they used a micro-GPS backpack unit [10]. They deploy their micro-GPS backpack units on wild turkey, monitor their movements and did some statistic tests [10]. They compared their results with results from the VHF telemetric methods, which were standard methods for tracking wild turkey before micro-GPS [10]. The results show that micro-GPS have the potential to provide increased reliable data on turkey movement ecology and habitat selection at a higher resolution than conventional VHF telemetric methods [10].

A study was conducted to learn about the foraging behavior of lesser noddy anous tenuirostris [11]. In this study MicroGPS were used to track these sea birds and the MicroGPS weight is approximately 2.0grams [11]. In this study 17 sea birds were tracked and the "Micro-GPS loggers were attached to the most retrices of breeding individual" [11]. All MicroGPS were recovered and the results were, lesser noddies mainly foraged in southwesterly direction and they return in the afternoon [11].

There is an article [12] about the study of bird behaviour at multiple scale. In this study tracking devices and bio-loggers were used to provide information on behaviour of birds in their environment [12]. Their GPS tracker weighted 12grams, this includes the microprocessor, data storage, battery and GPS receiver [12]. The tracking system had to meet the following requirements, it must be flexible, it must provide location in 3 dimension and it must also allow flexible measurement scheme [12]. The GPS tracker is fortified with a radio receiver which allows data to be downloaded and uploaded remotely [12]. Tests were conducted and the results were as follows, the GPS tracker produced a mean error of 1.13m in position [12]. The GPS tracker uses the time in between intervals to triangulate its position and it uses up to 9 satellites [12].

There is a report [13] about the study of Testudo hermanni boettgeri in Eastern Hermann. The aim of the study was to get data on the movement of wild animals [13]. For this study micro GPS devices were used with an addition of VHF transmitters [13]. The dimensions of the micro GSP are not specified. Six Testudo hermanni of which four were female and two were male were the test subjects [13]. Tested were conducted by calculating their range from home [13]. The results of the study indicated that there was no major difference in home range size between males and females and this is independent of the size of the Testudo hermanni [13].

A study [14] used micro GPS transmitter to study semi-aquatic nutria. The aim of the study was to study the environment and movement of Myocastor coypus [14]. The size of the micro GPS is not mentioned; the Myocastor weight was between 3 to 9 Kg [14]. Their collar consisted of a VHF transmitter, micro GPS and an antenna cable which formed a circular collar [14]. These collars were attached around the neck of Myocastor [14]. Tests were conducted in trials and the following were the results obtained. During the first trial 4 out of 5 test subject showed lesion and this was fixed for the second trial [14]. After that everything went well and the results were excellent [14].

There is an article about the study of shearwater in the Mediterranean Sea. The aim was to study the movements of shearwater in the Mediterranean Seas [15]. The GPS loggers were less than 9 grams in weight with dimensions of 0.787402 x 1.5748 x 0.23622 inches and the GPS loggers were waterproof [15]. To attach the GPS, birds were captured twice the first time was to attach the GPS and the second time to retrieve the GPS [15]. Tests were conducted and the results were as follows. The tests indicated that the shearwaters interchangeably used one of the two areas for fishing [15].

3 USER REQUIREMENTS

3.1 User View of the Problem

The Anti-Crime platform will be used by anyone who wants to keep track their property, whether you live in a crime free area or not, whether you are rich or poor because it will be low cost and whether you are young or old. The platform does not require literate people because it will be easy to use and people wants easy to use applications. Potential users would like to initiate tracks in alternative ways (from mobile phones or website) and they would also like to monitor and control their tracks.

3.2 Brief Description of the Problem Domain

The aim of the project is design and implement an IoT Anti-Crime platform for tracking property such as a handbag using MicroGPS chips. The chips will constantly sends information on the location of the property to a server. The information will be sent to the user and the user chooses to relay the information to authorities or not. The idea is to get the exact location of the property and maximize the battery life.

3.3 Software Solution Expectations

The user expects the MicroGPS chip to provide accurate locations of the property. User does not expect to get 20km radius location of the property. User expects the battery life to be long. User does not expect a track to fail after just an hour or two of tracking. Users expect to start a track even from their smartphones. The user expects the product to be a low cost solution. User does not expect to pay a value almost equivalent to the value of the property to be tracked.

3.4 Use Cases

Figure 1: Use cases diagram

4 REQUIREMENTS ANALYSIS

4.1 Functional Requirements

This section describes the functional requirements of the Anti-Crime platform application.

4.1.1 Creating an account. In order to access the system, you need to be registered. Registration requires the following information: first name, last name, email address and cell number.

4.1.2 User Login. After creating an account you will obtain a unique username and password. The unique username and password will be your login info and after login, the application will take you to the home screen. In situations where you forgotten your password or username, the system can send them to you via email.

4.1.3 Creation of a track. To create a track you just click the track tab in the home and provide details to the fields required.

4.1.4 Deleting a track. A user can remover/delete a track from the track list.

4.1.5 Delete a user (manager). The manager can remove/delete any user in the system.

4.1.6 View track. The manager can view all tracks in the system.

4.1.7 Relay info. The user must have capability to relay the info (location of the property).

4.2 Non-Functional Requirements

4.2.1 Performance. The application should be fast in terms of response. You cannot wait like 2 minutes to load a page.

4.2.2 Reliability. The system should provide accurate coordinates (position of the property).

4.2.3 Ease of Use. It should be easy to navigate the system. User home picture for home button, back arrow for back and other things to make navigation is.

4.2.4 Energy Efficiency. The tracker must send location to the server after a specific interval (be off in between the intervals) to prolong battery life.

4.2.5 Low Cost. The solution must be a low cost solution.

4.3 System Requirements

Different hardware and software components are required by the system.

4.3.1 Software Requirements. The following are the software required for the application: Java, MySQL, Adobe XD, and Python.

4.3.2 Hardware Requirements. The following hardware is required: MicroGPS chip, SIM card, laptop/PC.

4.4 Functional Decomposition

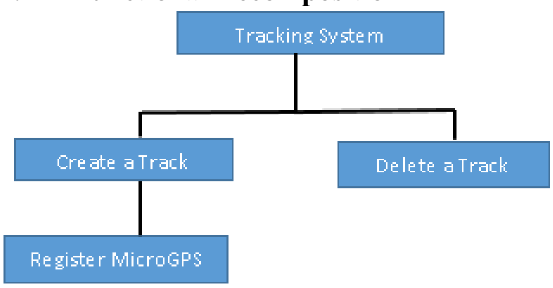


Figure 2: Functional Decomposition diagram

5 USER INTERFACE SPECIFICATION

This section describes how the interface of the application will be like without getting into detail. To move through the page/tabs, you use a mouse (right click on the tab you want).

5.1 Log in Page

Log in page is the first page of the application, it is where you get access to the application; here you log in using your username and password.

5.2 Registration Form

In case you don't have an account a registration button is available in the log in page, click it and fill the form to gain access.

5.3 Home Page

After the log in page it's the home page. Home page contains tabs to pages like track management where you create and delete track and a notification tab.

5.4 Track Page

This is where you manage your tracks, you can either create a track, delete a track or observe your track.

6 ARCHITECTURE

The architecture below is designed from the proposed solution. It clear outlines how the system will work or interaction between systems. According to this architectural design the MicroGPS chip will send location data to the control center (servers) where analysis will be conducted. The control center will send the location information to the application where the user will view the location information and make appropriate decision about what to do with the information. From the application the user is able to send control information to the control center. Control information like adding a property to track. The control center will send the control data to the MicroGPS chip.

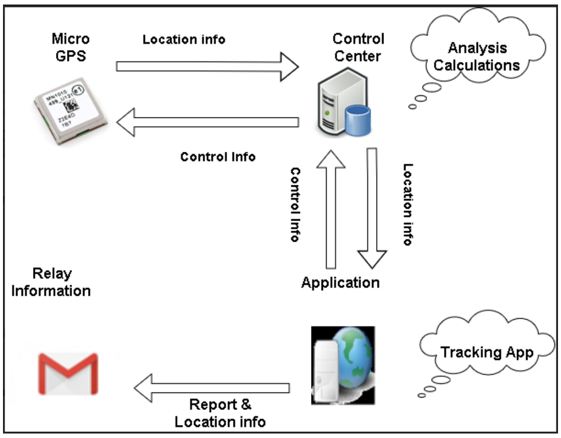


Figure 3: Architectural design of the proposed solution

7 PROTOTYPE

The following is my prototype and it will be showing how the application will look also highlighting some feature. This prototype design contains almost all the screens and functions of the application.

7.1 Home Screen

The home screen is the first thing you will see in the application. Home screen it is where you choose either to login or create an account.

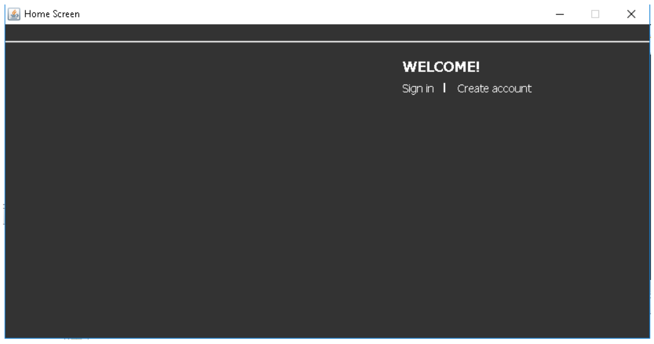


Figure 4: Home screen design

7.2 Login & Registration Screen

Figure 5(a) shows the login page where you input your e-mail and password to gain access to the system assuming you have already registered. Figure(5b) shows the registration screen.

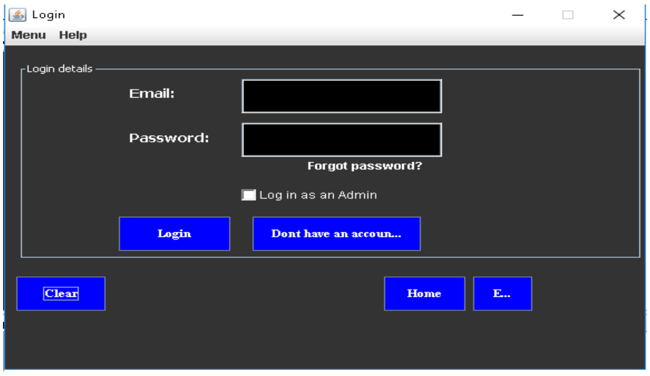


Figure 5(a): Login screen design

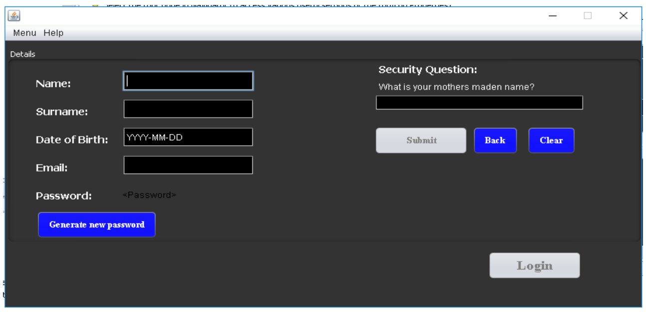


Figure 5(b): Registration screen design

7.3 Tracking Screen

The tracking screen consists of many functionalities. In this screen you can add a property to track or delete one. You can start tracking or terminate tracking.

Figure 6: Tracking Screen

7.3 Location Screen

The location screen pinpoints your property location on the map.

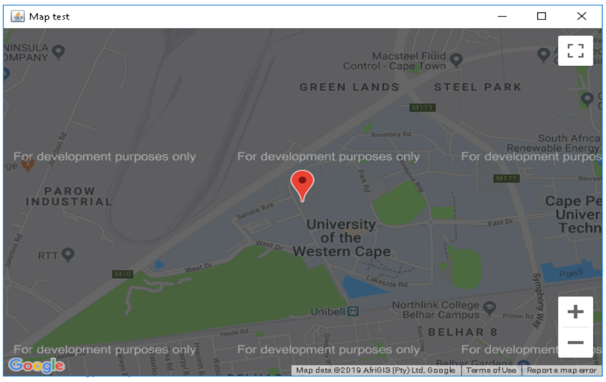


Figure 7: Show location on the map

8 CLASS DIAGRAM

The class diagram below shows classes and their attributes for the anticipated system. This class diagram is designed according to the requirements of the system.

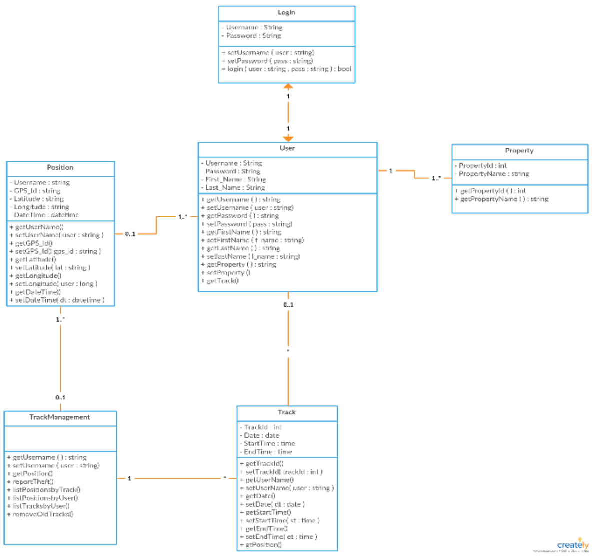
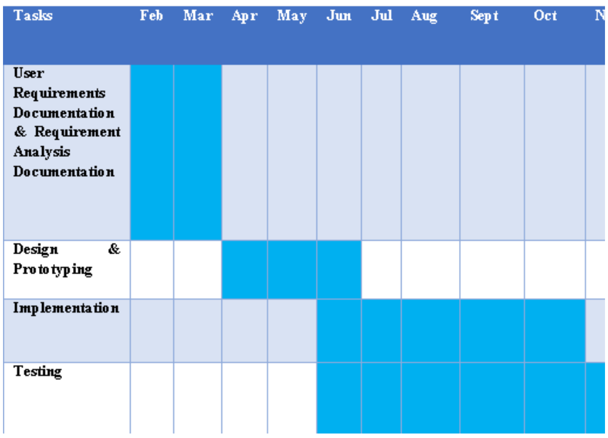


Figure 8: Class diagram of the system

9 PROJECT PLAN



Appendix A: Project plan in Month Interval

Bibliography

[1] Gabriel Demombynes, Berk Ozler, "Crime and Local Inequality in South Africa," The World Bank Development Research Group, November 2002.

[2] Martin Schönteich, Antoinette Louw,, "Crime in South Africa: A country and cities profile," Institute for Security Studies, 2001.

[3] S. C. Wu, W. I. Bertiger,D. Kuang, S. M. Lichten, S. Nandi,L. J. Romans,J. M. Srinivasan, "MicroGPS for Low-Cost Orbit Determination," TDA Progress Report, 1997.

[4] P. M. N. Kulkarni, "THE GLOBAL POSITIONING SYSTEM AND ITS APPLICATIONS," Department of Civil Engineering Indian Institute of Technology, Bombay, Powai, MUMBAI – 400076.

[5] Shital Mohol, Pavanikar, Ganesh Dhage, "GPS Vehicle Tracking System," *International Journal of Emerging Engineering Research and Technology*, vol. 2, no. 7, pp. 71-75, October 2014.

[6] Yahya S. H. Khraisat, Mohammad A. Z. Al-Khateeb, Yahya K. Abu-Alreesh, Anas A. Ayyash, Osama S. Lahlouh, "GPS Navigation and Tracking Device," *ResearchGate*, vol. 5, no. 4, pp. 39-41, October 2011.

[7] Sudhanshu Janwadkar, Dipak Bhavar, M.T. Kolte, "Design and Implementation of a GPS based Personal Tracking System," IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES-2016), Pune, India, 2016.

[8] Jacek Rapinski, Dariusz Tomaszewski, Mateusz Kowalski, "Analysis of the code and carrier phase measurements performed with LEA-6T GPS receiver," in *The 9th International Conference “ENVIRONMENTAL ENGINEERING”*, Lithuania, 2014.

[9] Laura A. McMahon, Janet L. Rachlow, Lisa A. Shipley, Jennifer S. Forbey, Timothy R. Johnson, Peter J. Olsoy, "Evaluation of micro-GPS receivers for tracking small-bodied mammals," *McMahon et al*, vol. 12, no. 3, pp. 1-19, 16 March 2017.

[10] JOSHUA D. GUTHRIE, MICHAEL E. BYRNE, JASON B. HARDIN, CHRISTOPHER O. KOCHANNY, KEVIN L. SKOW, ROBERT T. SNELGROVE, MATTHEW J. BUTLER, MARKUS J. PETERSON, MICHAEL J. CHAMBERLAIN, BRET A. COLLIER, "Evaluation of a Global Positioning System Backpack Transmitter for Wild Turkey Research," *The Journal of Wildlife Management*, vol. 75, no. 3, p. 539–547, 2011.

[11] CHRISTOPHER A. SURMAN, LISA W. NICHOLSON, STEPHEN AYLING, "FORAGING BEHAVIOR OF THE LESSER NODDY ANOUS TENUIROSTRIS FROM THE EASTERN INDIAN OCEAN: INSIGHTS FROM

MICRO-GEOLOGGING," Halfmoon Biosciences, Australia, 2017.

[12] Willem Bouten, Edwin W. Baaij, Judy Shamoun-Baranes, Kees C. J. Camphuysen, "A flexible GPS tracking system for studying bird behaviour at multiple scales," Springerlink.com, 2012.

[13] Oguz Türkozan, Sezgin Karaman, Can Yılmaz, Celal Ülger, "Daily movements and home range of Eastern Hermann's Tortoise, Testudo hermanni boettgeri (Reptilia: Testudines)," Department of Biology, Faculty of Science and Arts, Adnan Menderes University, Aydın, 2018.

[14] G. Michael Haramis, Timothy S. White, "A beaded collar for dual micro GPS/VHF transmitter attachment to nutria," USGS Patuxent Wildlife Research Center, 2011.

[15] G. DELL'ARICCIA, G. DELL'OMO, B. MASSA,F. BONADONNA4, "First GPS-tracking of Cory's shearwater in the Mediterranean Sea," *Italian Journal of Zoology,* vol. 77, no. 3, p. 339–346, 2010.