

# Development of an Android Mobile Application for Cycle users of the City of Bogotá D.C.

Hernan Paz Penagos, Ph.D<sup>1</sup>

<sup>1</sup>ESCUELA Colombiana de Ingeniería JULIO GARAVITO, Colombia, hernan.paz@escuelaing.edu.co

*Abstract—This article is about the development of an application for smartphone phones with Android operating system for cycle route who transit in the city of Bogota D.C. The development of the project was achieved with the help of a methodological process, which was structured in four phases, these phases are described: the general context of applications developed in Android, needs identification of cyclical, mobile application development, validation and results; The coupling of these stages allowed to analyze the current situation and to design, program and implement an application according to the needs of the study population, in order to encourage the use of the bicycle as a means of transport for sustainable mobility. The application developed includes the following functionalities: georeferenced maps of the network of cycle route and bicycle route of the city of Bogota, by selecting a source point and a destination point a route is generated, which is drawn on a map, which has in The possibility of users having information on the status of the cycle route through the qualification of the state of the road, lighting and signaling, search for parking cycle, creation of public or private points of interest such as bicycle stores, Workshops of repair, hydration points, among others, history of the route made with information of the time spent in making the route and access to the information of events and tips.*

Keywords-- Android; mobile app; cycle route; Google maps; Bogotá.

Digital Object Identifier (DOI):

<http://dx.doi.org/10.18687/LACCEI2017.1.1.43>

ISBN: 978-0-9993443-0-9

ISSN: 2414-6390

# Development of an Android Mobile Application for Cycle users of the City of Bogotá D.C.

Hernan Paz Penagos, Ph.D<sup>1</sup>

<sup>1</sup>ESCUELA Colombiana de Ingeniería JULIO GARAVITO, Colombia, hernan.paz@escuelaing.edu.co

*Abstract—This article is about the development of an application for smartphone phones with Android operating system for cycle route who transit in the city of Bogota D.C. The development of the project was achieved with the help of a methodological process, which was structured in four phases, these phases are described: the general context of applications developed in Android, needs identification of cyclical, mobile application development, validation and results; The coupling of these stages allowed to analyze the current situation and to design, program and implement an application according to the needs of the study population, in order to encourage the use of the bicycle as a means of transport for sustainable mobility. The application developed includes the following functionalities: georeferenced maps of the network of cycle route and bicycle route of the city of Bogota, by selecting a source point and a destination point a route is generated, which is drawn on a map, which has in The possibility of users having information on the status of the cycle route through the qualification of the state of the road, lighting and signaling, search for parking cycle, creation of public or private points of interest such as bicycle stores, Workshops of repair, hydration points, among others, history of the route made with information of the time spent in making the route and access to the information of events and tips.*

*Keywords-- Android; mobile app; cycle route; Google maps; Bogotá.*

## I. INTRODUCTION (HEADING 1)

Bogota, as in many cities in Latin America, has high traffic congestion, mainly during peak hours, due to the high volume of vehicles and the number of people traveling on the roads. Congestion is also reflected in the waiting time at *Transmilenio* stations, especially on atypical days such as the day without a car. This implies that the citizens contemplate the possibility of changing the way of mobilizing within the city and using the bicycle as transportation.

With respect to the city of Bogota, this has become a reference worldwide in the use of the bicycle, in recent years have built around 350 km of cycle routes, and recently 5km of bike lanes. The city has about 600,000 cycle route [1], who find limitations when using the cycle routes; Such as: lack of maintenance of infrastructure, Insecurity in cycle routes, lack of illumination of some sections, poor signage, lack of connectivity between the cycle network with bike lane and long travel times, all of this has prevented this Alternative [2].

To mitigate some limitations and to encourage the use of the bicycle, we propose a development of a mobile application in Android for the cycle route of the city of Bogota. This development offer an application with some functionalities (which will be explained later) and contribute to the promotion of the use of the bicycle as a means of transport, since according to the 2007 [3] and 2015 [4] mobility surveys, one

of the Reasons why people do not use the bicycle is the belief that the distance traveled is very long [5]. In addition, it aims to reduce travel times of the users' cycle with the use of the application, and improve mobility, quality of life (less pollution), well-being and health for the people of the city.

The methodology followed in the programming of the application, both client and server side, followed the model 4 + 1 views, which allowed to develop it through the logical, implementation, process and physical views. This approach favors a general, relational and particular conception, both as an architecture and as an entity - relationship model. It also facilitates the identification of development components and the logic followed to trace the shortest route.

The results obtained with the development of the application are: identification and tracking of the shortest route between a point of origin and a point of destination, in the network mesh cycle routes of Bogotá, location of the cycle parking closest to its position (Bicycle stores, repair shops and hydration points), information on events focused on the users cycle and finally, an option to qualify the status of the cycle route and / or bike lane : The system information is constantly updated.

## II. THEORETICAL FRAMEWORK

Smartphone applications have become tools of frequent use, for example, to locate restaurants, museums, libraries, bars, drugstores, stations and stops for public transport in a certain area. In the case of Bogotá there are applications for different needs, such as the search for real estate, public transport routes (SIP), homes, radio stations, *Transmilenio*, shopping, guides to move around in the city (such as *Moovit* for taxi drivers), among other.

### A. Mobile platforms

There are different operating systems for mobile platforms; But with respect to the purpose of this work, will mention Android Inc. The book Introduction to Android [6] defines it as an open source platform (freely distributed software) under the Apache license (foundation that supports open source software projects) and adaptable to any hardware which allows a greater freedom in terms of programming is concerned.

Android is based on Linux and was initially developed by the company Android Inc., acquired in 2005 by Google; is also the main product of the Open Handset Alliance, which has a global market influence of 50.9% surpassing iOS Apple (mobile operating system of the multinational Apple Inc.) [7].

The Android framework is composed of applications (in English, app) running in the Java (object-oriented language)

Digital Object Identifier (DOI): <http://dx.doi.org/10.18687/LACCEI2017.1.1.43>

ISBN: 978-0-9993443-0-9

ISSN: 2414-6390

**15<sup>th</sup> LACCEI International Multi-Conference for Engineering, Education, and Technology:** “Global Partnerships for Development and Engineering Education”, 19-21 July 2017, Boca Raton FL, United States.

environment on a kernel of libraries in a virtual machine called Dalvik [8]. This operating system has about 12 million lines of code, including 3 million lines of XML, 2.8 million lines of C, 2.1 million lines of Java and 1.75 million lines of C ++.

Apps for smartphones with Android operating system have become useful and everyday tools. The Google Play Store [9] is the official Android app store, and apps, games, music, eBooks and movies can be downloaded from the mobile phone or tablet. It is usually built in with the operating system or can be manually installed by downloading the file with .apk extension (Android application package) and contains the components of any application for the Android platform

### B. International and national context of the applications developed for cycle users with more downloads of the play store

As a criterion to contextualize the current situation of the applications take into account the amount of downloads and punctuation given by users in the official store of Android applications, information consulted on January 15, 2016 [9] such information is summarized in the Table I, which shows that the application of highest score is *bikecityguide* gps and bike routes, followed by I go on bike, bike and finally *wikicleta*, in that same order is presented the highest score High given by users.

TABLE I  
INTERNATIONAL APPLICATIONS SCORING

Application	Number of downloads	ranking)	
		User	Qualification
<i>En bici</i>	5.000 a 10.000	86	3.6
<i>Me voy en bici</i>	10.000 a 50.000	60	3.8
<i>Wikicleta</i>	5.000 a 10.000	304	3.7
<i>Bikecityguide gps y rutas bici</i>	100.000 a 500.000	2.145	3.9

Source: Adapted from play store information.

The applications identified in Table I are briefly described in Table 2. Each one of them is useful information for cycle route as a map of cycle paths, cycle paths, bicycle availability, among other characteristics. The country where it is currently implemented; In addition to its secondary functionalities, such as bike repair shops, routes, route scoring, social events, etc. A common feature of the applications described in Table II is that the application's functionalities are located on a map, and have a web page, which displays information regarding the purpose, functionality, description and main features of the same application; In addition to offering an option for the input of comments by the users.

TABLE II  
OVERVIEW APPLICATIONS ON ANDROID AT INTERNATIONAL LEVEL

Application	Item evaluated	Detail
On bicycle [10]	General description	Application that shows the availability of bike lane at <i>Ecobicis</i> stations (bicycle rental stations). In addition it locates parking of bike lane (bicycle) and routes for the displacement in the city (bike paths).

**Digital Object Identifier:** (to be inserted by LACCEI).  
**ISSN, ISBN:** (to be inserted by LACCEI).

	Countries	Argentina (Buenos Aires)
	Operation	The user from his mobile phone, through a menu of options in the application has the possibility to select one or more elements that are shown in the map, which are identified by icons.
	characteristics	Public bicycle stations, local of user's cycle, bike lane (bicycle repair shops), bicycle (bicycle parking), cycle routes and bike paths, prefer preferred lanes, references on the map.
	Map	Google Maps
	Free	Yes
	Updated	27-feb-16
	Size	4.3 Mbytes
	Android required minimum	4.0.3
	Web page	<a href="https://www.facebook.com/enbiciApp">https://www.facebook.com/enbiciApp</a>
	I'm going on a bike [11]	General description
Countries		Argentina (Buenos Aires)
Operation		The user from his mobile phone can check the availability of bike lane (sorted by distance using the GPS) and the cycle path map.
characteristics		Cycle paths, premises for renting bike lane for tourists.
Maps		Google Maps
Free		Yes
Updated		06-dic-14
Size		3.2 Mbyte
Android required minimum		2.3
Web page		<a href="https://www.facebook.com/Mevoyenbici">https://www.facebook.com/Mevoyenbici</a>
<i>Wikicleta</i> [12]	General description	Information platform and interaction with bicycle users.
	Countries	México
	Operation	The user from his mobile phone registers where it includes his name, email address, username and password. Within the application has an options menu where you can view the items marked as favorite, draw a route from a starting point to an endpoint and events focused on bicycle users. The application shows a map with routes for users cycle and cycle parking
	characteristics	Hazard information tips, recommendations, places to visit by bicycle, which can be marked as favorites, view performance on a route, route score, bicycle parking.
	Maps	Google Maps

	Free	Yes
	Updated	31-ago-15
	Size	6.0 Mbytes
	Android required minimum	2.3
	Web page	http://wikicleta.com/
Bikecityguide gps y rutas bici [13]	General description	Calculation of routes for bicycle users.
	Countries	Europa, Germany
	Operation	Find the most suitable bicycle route for the user with GPS, with audio indications. Default tours to explore the city. According to the city where the application is used the map is downloaded.
	characteristics	Calculation of routes from a source point to an end point, shows and records: speed, time and distance, offline operation, lists with points of interest, guide with voice prompts.
	Maps	Open Street maps (OSM)
	Free	Install cycle to free function, and after 100 km traveled in 30 days by registering the route the map is free.
	Updated	22-jun-16
	Size	According to the device
	Android required minimum	According to the device
	Web page	http://www.bikecitizens.net/

In the national context and consulting the official store of Android applications for the city of Bogota there are many applications developed by Colombian companies and/or foreign companies, being useful for people who live and discover the city. Some examples of the above mentioned are: search and consultation of real estate (sale and rent trovit houses, BIINMO: Colombian real estate, *FincaRaiz* - sale and rent), guide and use of public transport (moovit, uber, tappsi, Communications (*ElTiempo*, *Elespectador*, *TuneIn radio*, *FM radio*), use of the Transmilenio transport system (Transmilenio), service for order food (domicilios.com - *requests food*, *eats already* - *food at home*, *rappi*, *frisby*) And Sitp, Transmilenio Routes and SITP). The mentioned applications can be consulted in the play store.

This store also identifies others focused on bicycle users in the city of Bogotá, to follow sports activities in the modalities of walk, route and mountain, such as: *runtastic*, *runkeeper*, *endomodo* and *my tracks*, also counts With applications for routing, which provide information on the cycle and location of cycle parking's, workshops, bicycle shops and social events for the users of this means of transport.

The mobile and desktop applications listed below in Table III were developed to route -establish a route between a source address and a destination address: (Ablitas Wall JG, 2013) -

and geo locate the location of a spatial object either by a point, vector, area or volume (Ablitas Wall JG, 2013). Table III shows the applications ride the city, *bicimapa* and *mejor en bici*, in terms of its operation, operating system, type of map used, type of application (desktop and/or mobile), features, version Minimum required operating system and last update date according to the download store.

TABLE III  
OVERVIEW OF SOME APPLICATIONS ON ANDROID AT NATIONAL LEVEL

Application	Items evaluated	Detail	
Ride the city [14]	General description	Safe routes for cycling in the city through a website that allows you to find the shortest distance between two points.	
	Countries	Spain (Barcelona), Colombia (Bogotá), United States (Chicago, San Francisco), Chile (Santiago de Chile)	
	Operation	Web service that traces a route from a source point and endpoint for the users of the application, with criteria such as: the most secure route, the safe route and the direct route; Taking into account the distance and the estimated time for the route The route calculated by the consumption of the web service can be qualified as: excellent (what the user would have done without the application), very good (similar to the best possible route), good (use several common turns), Wrong, terrible from beginning to end.	
	characteristics	Tracing routes, bicycle shops, route Rating	
	Maps	Open Street Map (OSM)	
	Free	Free for desktop version.	
	Application Type	Mobile (iOS), desktop (web page)	
	Available	App store	
	Updated	07-jun-13	
	Size	4.4 Mbyte	
	Android required minimum	4.3	
	Web page	http://es.ridethecity.com/bogota	
	<i>Bicimapa</i> [15]	General description	It allows the users of the application to share the other members, information related to events, cycle parking's, and public bike lane, among others. Map with information of cycle route grouping them by exclusive routes for cycle route and recreational routes for the city of Bogota (Colombia) that aims to encourage the use of the bicycle.
		Countries	Colombia

Application	Items evaluated	Detail
	Operation	Using the API key of google maps, the user visualizes the information sent by the users about: events for cycle route, public bike lane, cycling friends, shops, and bicycle repair shops, cycle parking's and bicycle rental. It shows cycle routes, cycle paths and reports on hazards to users at a specific point.
	Characteristics	247 parking lots, 184 stores for bicycle users, 202 workshops, 14 bad route warnings, map with the main city cycle route.
	Maps	Google maps
	Free	Yes
	Application Type	Mobile (Android, iOS), Desktop (web page)
	Available	Play store
	Updated	12-jun-14
	Size	2.1 Mbyte
	Android required minimum	2.2
	Web page	<a href="http://www.bicimapa.com/">http://www.bicimapa.com/</a>
<i>Mejor en bici</i> ® [16]	General description	Promote the use of the bicycle through strategies in companies and universities.
	Countries	Colombia
	Operation	Web page that contains a blog (weblog) of the main news about the use of the bicycle. You have the option to show on the map of the city of Bogotá the cycle routes, that to be selected indicates the address where it is located. By entering the email and selecting a company or university to which the user belongs, he will be given a bicycle that is part of the system of Shared Bike lane (SIBUC®).
	characteristics	Information of interest to bicycle and SIBUC® users, cycle parking's, shopping for bicycle items.
	Maps	Google maps
	Free	Yes
	Application Type	Desktop (web page)
	Available	Does not apply.
	Updated	Does not apply.
	Size	Does not apply.
	Android required minimum	Does not apply.
	Web page	<a href="http://www.mejoren bici.com/">http://www.mejoren bici.com/</a>

With respect to the national context, it is concluded that the applications available to users of bike lane in the city of Bogotá present unique functionalities within each application, highlighting the route layout, adding points of interest, visualizing the cycling routes, options for reports on hazards in

Cycling, events for cycle route and bicycle shops. In terms of application limitations can be mentioned the lack of integration of multiple functionalities in a single application; Which does not allow the user to identify if the route drawn in the case of the Ride the city application belongs to a route of special use for cycle route or not, nor do they provide a status classification of the cycle route taking into account the signaling, Pavement and lighting, etc.

Next, in table IV a comparative analysis of the characteristics for the applications in the national and international context is made, with respect to the visual components, logic of the application and functionalities; In order to identify their shortcomings and propose an application that overcomes some of these limitations.

TABLE IV  
COMPARISON OF SOME FUNCTIONALITIES OF THE MOBILE APPLICATIONS IDENTIFIED IN THE NATIONAL AND INTERNATIONAL CONTEXTS

Operation	Result
Graphic interface	The graphical interface of applications refers to the control that the user has over the application with respect to the functional part and interaction that the user has with the application. Within the applications stand out two by the functionality that they present to the interaction with the user Ride The City and Bikecityguide Gps and Bike Routes since they are applications that have a defined approach to the user emphasizing: the calculation of the routes in a source point and a destination point, user interaction with the map, use the base map of open street map.
Logic of the application and interfaces	This item refers to the response of the application to the other functions of the phone such as phone calls, camera, Internet use and other features of the device operating system. The applications work in the background, this indicates that while they are used can receive or make calls, that is, use asynchronous tasks.
Multi-platform application	A multi-platform application corresponds to an application running on different platforms while maintaining the same functionalities. Within the applications analyzed it is observed that of the seven applications two do not have an application to work on a mobile device with Android operating system. The main advantage over an application is programmed in Android, corresponds to: Open source platform, this indicates that you can develop applications based on C language or other languages and compile them to native Army code (Android API). None of the applications are scheduled on BlackBerry Os and Windows Phone. The application <i>Me voy en bici</i> , is the only one that does not have a web page, so the only information that was found was related in play store.
Main and additional features	The functionalities of the applications are summarized below: Main Functionalities: map display, display of cycle lines, calculation of the safest route, by entering source point and destination point. Additional Features: cycle parking's, shopping for bicycle items, points of interest, calculation of distance, monitoring in nutrition and heart rate

One of the shortcomings of the applications corresponds to the lack of information on the state of the network of cycle

routes, in addition they are of informative character: they show on the map the location of cycle routes but the user cannot interact with them. Another weakness is that they do not give options to save the history of the route traveled or to look for a near cycle parking's. This was an opportunity to develop the research work presented in this article.

### III. METHODOLOGY

The methodological design identifies four phases that correspond to: 1) analysis of the state of the art on mobile applications in the national and international context, 2) identification of user cycle needs in Bogotá, based on a questionnaire survey of seven Questions, 3) design and implementation of the application, which includes programming logic for the functionalities, and finally, 4) tests according to a protocol, results and field validation of the programmed functionalities, in order to make the relevant adjustments.

In this research work two types of research were applied: exploratory and descriptive. Phases 1 and 2 were part of exploratory research, which sought to examine a poorly studied subject [17]; In this case, the state of the art on mobile applications for user cycle was revised in the national and international context. In addition, an instrument was used to collect primary information on needs perceived by users of cycle routes, and surveys were conducted by the District Mobility Secretariat in recent years.

Phase 3 and phase 4 corresponded to a descriptive type of research, in that it was sought to design and implement an application based on the needs of individuals, groups, communities or any other phenomenon subjected to analysis [17]: The input of the development was the information collected in phases 1 and 2. The final product was BICO meets some needs detected in the users of the cycle routes of Bogota, and overcomes some limitations of commercial mobile applications for users cycle identified in the National and international contexts.

The master design for primary information collection was determined using probabilistic samples. According to Sampieri and Baptista (1991) each member of the population has the same probability of being selected as subject, for this it is decided to use a simple random sample, and thus determine the number of surveys to apply. Lohr [18] indicates that when the size of the population is unknown, the equation that relates the precision and sample size comes from the confidence intervals, using the equation (1):

$$n = \frac{Z_a^2 pq}{d^2} \tag{1}$$

Where

$n$ : Sample size

$Z_a$ : Confidence level

$pq$ : Variance of the sample

$d$ : Precision

According to the above, the sample design yielded 384 surveys for a 95% confidence interval. For the application of the surveys, three zones are selected that are shown in the fig.1.



Fig 1. Division of zones – 2013 studies. Source: Special report 14: Cycle routes Bogotá

The specific points of application of surveys in the zones shown in the previous map were selected from the special report 14: Cycle routes Bogotá [19], which tracks the use of the city's cycling system Of Bogotá, elaborated by the Consortium Monitoring Transit and Urban Transportation Bogotá. Based on this study, the three of the highest traffic of related cyclers were chosen in the performance. In Figure 2, the location of the collection points of the information where the surveys were applied in the city of Bogotá is shown. According to the above, the sample design yielded 384 surveys for a 95% confidence interval. For the application of the surveys, three zones are selected that are shown in the fig. 2.



Fig 2. Location of the information points. Source: Author.

At these points, users of bike lane were surveyed on the streets, bicycle lanes and urban groups of cycle route (communities of cycle route meeting in different locations in Bogota) [20]. The requirements shown in Table V were identified for the development of an Android application for users of cycle routes in Bogotá.

TABLE V

REQUIREMENTS IDENTIFIED

Code	Requirement Name	Description
RI – 001	Portability	The application must be installed on any mobile device with Android Operating System.
RI – 002	Location	The application must display the location on a map of the city of Bogota.
RI – 003	Upgrade	The application must have the location information of cycle route on platform and causeway within the city of Bogotá.
RI – 004	Graphic interface	The application must be user friendly and easy to use.
RI – 005	Security	The application must have user authentication by using password.
RI – 006	Location	The application will plot the route to arrive from a point origin to a destination point
RI – 007	Location	The application will show the bicycle parking and repair shops.
RI – 008	Upgrade	The application must keep the status information of the cycle route updated.
RI – 009	Record	The application must have a history of the routes performed.
RI – 010	Points of interest	The application will have the option of saving new points of interest that are public or private as hydration points, fell police, bicycle repair shops, among others.
RI – 011	Notifications	The application will give users information on events for cycle route and some additional tips.

On the Table VI was documents the final characteristics obtained from the phases completed in phases 1 and 2 for the design, programming and implementation of the mobile application; in which the name of each functionality is indicated with the respective description.

TABLE VI  
APPLICATION FUNCTIONS

Features	Description
Path mapping including the cycle network	The main functionality corresponds to the location of a start point (origin) and an end point (destination) on the map by the user, that the application draws the shortest route with priority for the tracks for cycle route.
Location of cycle parking	According to the current position of the user if the user wishes to have the option that the application is located the nearest cycle-bank.
Points of interest	The user has the option to save specific points that are displayed in google maps, this is done by entering a name and description. The display is displayed by an icon that the user chooses from a list.
Saves track history	The user will save the history of the routes traveled with the option of time and distance.
Location of bicycle repair shops	Through the points of interest the user will include bicycle repair shops.
Reports the status of the Cycle route	The status of the cycle can be reported by users taking into account the status of the infrastructure, which will be validated by other users before being public in the application, for this will be given an average rating.
Information integrated in a single application	The functionalities will be integrated in a single interface, friendly, intuitive and easy to use.

Once, the requirements were identified, we proceeded to design the application architecture, we programming the logic in the server and mobile device, for this we followed the structure of Fig. 3.



Fig 3. Mobile application programming structure.  
Source: Author.

The steps for the application programming were: first the project is created in Django [21], the database in PostgreSQL [22], then the information of the routes that is contained in the shapefiles (format of data storage of Esri to store the location, form and attributes of geographic entities: these are stored as a set of related files and contains an entity class) corresponding to the archives of information of the cycle routes and bike lanes information, and that are a complement to the *PostGIS* database [23]. Next, the web administrator's logic is programmed, and finally, the web service is programmed for the Android connection. Parallel to these described steps, the development of the mobile application for the Android operating system is performed.

BICO is supported in a client - server architecture, consisting of four parts: server, mobile device, web administrator and Google Maps API.

Fig. 4 shows the WEB manager and the subsystem called the mobile device, which is made up of the smart phone, the BICO application and the SQLite database; both are considered clients within the architecture. The server contains the database and application in Django that manages and provides information to the client "mobile device" about routes, parking cycles, points of interest, etc.



Fig 4. General structure of the application. Source: Author.



For BICO to work properly, it is required to use web services offered by third parties, in this case: google maps API v3.0. The web administrator and the mobile device make requests and transactions to the server; to meet them, the server connects to the application in Django, and it runs the algorithms and connections to the PostgreSQL database. These store the information related to the cycle routes of the city of Bogotá and other data of the system [24]. For the calculation of the possible routes that a user cycle can follow, the application resorts to the contest of Django and google maps. Django accesses through the server. This is shown in Fig. 5.

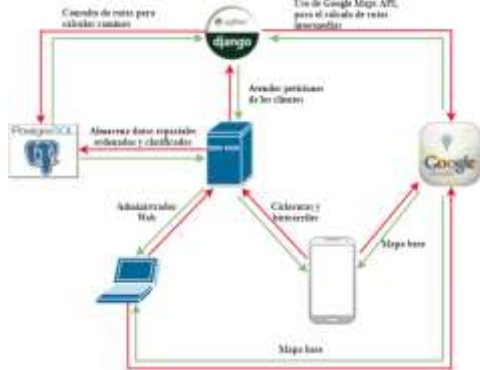


Figure 5. Application architecture. Source: Author.

For the validation of the results a test protocol is designed, for this the conformity/nonconformity of a group of functionalities that are the expected result of the application is evaluated. The tests were carried out in the field, with the installation of the .apk file on two smartphones's.

#### IV. RESULTS

The software of the BICO application provides software to the following functionalities: 1) updated information with georeferenced maps of the network of cycle routes network of the city of Bogota, which is supplied by the Institute of Urban Development (IDU), 2) Improving mobility within the city by drawing a route, taking into account the cycle routes and / or bike lanes to reach from a point of origin to a point of destination, 3) gives the possibility for users to have information about the route. Status of the route cycle through it sent from the rating of this to the application, 4) allows the search of cycle parking near the user's location, 5) has the option to create points of interest for the public user and/or private as: bicycle stores, repair shops, hydration points, among others, and 6) allows to create a history of the route made with information of the time spent in making the journey.

The development of BICO also took into account the degree of use; This is a main characteristic of any mobile application, as it is recommended to give attributes such as ease of learning (first time a user uses an application), effectiveness (tasks solved in a limited time), content (information shown to the user), portability (Step from one platform to another), efficiency (time taken to complete a task) and context (variables or factors of the environment of use of

the application), which allows the user to have ease of interaction and use of the respective functionalities, in order to design and program a graphical interface that differentiates it from the current mobile applications for bicycle users in the capital city.

Two results of the development were the graphical interface, seen from the web administrator, and the mobile application implemented for smartphones with Android operating system version 4.4 or higher. This application can be cataloged as the native type, because it works only with Android operating system, and makes use of the functionalities of the phone, in this case the GPS, allowing it to adapt to the characteristics of the mobile phone.

As for the web administrator for the management and administration of the data in the mobile application, the following results were obtained:

A map of the city of the network of cycle route and bicycle route in Bogota (see Fig. 6).



Fig. 6 Cycle routes and bike lane. Source: Author

Calculation and mapping of a route from a source point to a destination point on a map, taking into account the network of cycle route and bike lane (see Fig. 7).



Fig. 7. Route calculation. Source: Author.

Registered users in the system (see Fig. 8)

Usuario	Nombre	Apellido	Ultimo ingreso
user1	John	Alfonso	Nov. 7, 2016, 10:10 p.m.
user2	Tina	Alfonso	Nov. 7, 2016, 10:10 p.m.
user3	John	Alfonso	Nov. 7, 2016, 10:10 p.m.
user4	Tina	Alfonso	Nov. 7, 2016, 10:10 p.m.
user5	John	Alfonso	Nov. 7, 2016, 10:10 p.m.
user6	Tina	Alfonso	Nov. 7, 2016, 10:10 p.m.






Fig. 8. Registered users.





Source: Author.



As for the achieved results of software design and development in the mobile application. Table VII shows the functionalities of the application with its respective image.



TABLE VII.  
RESULTS OF SOFTWARE DESIGN AND DEVELOPMENT

Functionality	Result
Register a user in the mobile application from his smartphone.	 <p>User registration.</p>
Login of a user in the mobile application from his smartphone.	 <p>Login.</p>
The updated information with georeferenced maps of the network of cycle route and/or bike lane of the city of Bogotá and duration of the route.	 <p>Red of cycle routes and/or bicycles.</p>
Calculation of a route that includes the network of cycle route and / or bicycles lane to get from a point of origin to a point of destination, which is drawn on the map of google maps used by the mobile application.	 <p>Route calculation.</p>
Information on the cycle and sent of the qualification with respect to the state of the pavement, lighting and signaling of the same.	 <p>Rating status cycle route.</p>

Functionality	Result
Add points of interest for the public and / or private user such as: bicycle stores, repair shops, hydration points, among others.	 <p>Add point of public and/or private interest.</p>
History of the route made with information of the time spent in making the route.	 <p>Tour history.</p>
Main menu to access the main functionalities of the application, track history, community with event information for cyclers, configuration and finish the active session within the application.	 <p>Main menú.</p>
Access to the main functionalities of the application: search for a parking bike, add points of interest, points for calculating the route (start of route and end of route).	 <p>Main features.</p>

Functionality	Result
Access to general information on events for cycle route.	 <p>Main features.</p>
Displays the current location of the user in the application map.	 <p>Current location.</p>

On summary, the development of the application for users cycle of the city of Bogotá, is calculated and traced a route taking into account the network of cycle route and bike lane, on a map and shows secondary functionalities, according to the collection of information and situation Current applications for cycle users. With the above, the general objective and the specific objectives proposed in the research are fulfilled.

## V. DISCUSSION OF RESULTS

The mastery of mobile applications is linked to technological advances, where when designing an application must take into account the user's views and technological limitations, to improve the experience with regard to design and use, to do so You must take into account the type of device, the operating system and the purpose of the application.

As for software it can be mentioned: for the operation of the mobile application for cyclers it is necessary to connect to the web server implemented in Amazon, with a public IP, since it allows to make the queries on the calculation of the route, location of parking cycle, Query of interest points and other information that contains the application. The data regarding the network of cyclists and bicycles updated, uploading the information to the database in shape format.

For the design, programming and implementation of the application, the following done: server logic was developed using the Django development framework, which by means of a PostgreSQL database with the PostGis geographic data complement, containing the Route information and other information used by the application such as parking cycle, events and points of interest. In addition, it extracts information from all data and delivers it to the end user in an

easy and efficient way, through a web browser, which is manageable and administrable.

The main functionality of the application corresponds to the calculation of the route from a source point to a destination point, for this are made requests to the server, which attends the requests and in turn queries the route in Django; But because it does not have all the information of the map of the city of Bogota in shapefile format, uses the API of Google Maps that calculates the intermediate distances, for the passage between a cycle route and another, to make the connection these. In this case, you send the two points that you want to connect that correspond to the point where a cycle route ends and the point where the other cycle route with which you wish to connect begins.

The software of the mobile application installed on the smartphone, written in Java object-oriented programming, allowed the design of the graphical interface of the views, facing the user cycle, for it was made use of the Android Studio tool.

When testing of each of the functionalities verified that the mobile application integrated hardware and software, and was able to show users, the execution of each of the functionalities giving the information requested. The application has an easy-to-use and intuitive interface, which allows users to easily relate to each of their features.

The users were able to store the routes made and see the respective history with date, time and duration of the route, from the main menu of the application. From the community option, the users were able to see the cycle tours that are registered.

In summary, the development of the application for cyclists of the city of Bogota, calculates and traces a route taking into account the network of cyclists and bicyclists, on a map and shows secondary functionalities as points of interest, search of parking cycle, qualification of the state Of the cycle route and information of events and tips, according to the information collection and current situation of the applications for users cycle.

When designing this mobile application, it is intended to follow the guidelines of the Strategic Plan framed in the National Program for Technological, Industrial and Quality Development 2005-2015 of *Colciencias* Colombia, which includes research lines for telecommunications technologies, highlighting the development of specific applications in different fields Such as transportation, education, health, etc. On the other hand, the Ministry of Information Technologies and Communications (MinTic) and its Vive Digital plan, with its initiative Apps.co promotes and enhances the development of applications from the generation of capacities and ICT knowledge in a massive way Among Colombians. The project seeks to interrelate users of the bicycle to reduce travel times and accidents, using services based on information and navigation systems based on the location of an individual by

means of GPS and with an adequate cartography to trace the shortest route.

For future improvements of applications for cycle users, it is recommended to take into account the direction of the cycle route and/or bike lane in order to indicate to the user the sense of the way [25]; So that the functionality of entering the address of the point of origin to the destination point is included, to give the user greater precision of his location. In addition, have all the georeferenced map of the city of Bogota, so it is not necessary to use add-ons - as was the case with this development that uses coordinate information stored in google maps - to trace the shortest route.

#### CONCLUSIONS

About the questionnaire survey question about whether the user would be willing to send information to the application - for example, by rating the status of the cycle route, 298 users responded affirmatively. This is a good indicator that the BICO application can be kept up to date. In the event that it is necessary to update the database of the cycling and bicycling network, it is recommended to have the new information in shape format, so that it can be easily uploaded to the web administrator.

It was also possible to identify that the information of greatest interest for cycle route is to locate the bike repair shops (with 284 answers) and bike racks (with 244 answers). Accordingly, it was decided to create a functionality in the application called points of interest, allowing them to be displayed on a map with an icon that identifies them.

The calculation of the shortest route taking into account a point of origin and destination located in the network of cycling and bicycling in the city of Bogota, was made with the purpose of offering the user cycle an option of movement within the city; To achieve the above, a heuristic method was used, due to the multiplicity of variables that intervene to calculate this route.

The BICO application is supported in a client - server architecture, consisting of four parts: server, mobile device, web administrator and the Google Maps API. The WEB manager and the mobile device, which is made up of the Smartphone, the mobile application and the SQLite database; both are considered clients within the architecture. The server contains the database and the application in Django manages and provides information to the client "mobile device" about routes, cycle paths, points of interest, etc.

With the development of BICO some limitations of the applications for downloading to smartphone with Android operating system for cycle users in Bogotá were overcome; Among others, the following are mentioned: now if you have the information of the city's cycle route and bike lane; Information is also provided on the status of the cycle route, the shortest path in a path and information on points of interest in an integrated application.

#### REFERENCES

- [1] Secretaría Distrital de Movilidad. Informe de Indicadores: Encuesta de Movilidad de Bogotá 2011. Bogotá: *Alcaldía Mayor de Bogotá D.C.*, p.465, 2011
- [2] Ortega, A. S. Bicicleta y Movilidad Sostenible. *Eubacteria*,. Recuperado el 17 de Enero de 2016, de <http://www.um.es/eubacteria/eubacteria2/bicicleta.pdf>, pp. 30-31, 2009.
- [3] Velandia Durán, E. A. La movilidad en bicicleta como respuesta a la insostenibilidad del sector transporte. Realidad y desafíos en Bogotá. *Épsilon*, 11, Disponible en: <http://revistas.lasalle.edu.co/index.php/ep/article/view/1397/1274>, pp. 37-40, 2008.
- [4] Alcaldía mayor de Bogotá. Encuesta de Movilidad 2015. En: Sabana centro cómo vamos [en línea]. [consultado 12 de agosto 2016]. Disponible en <http://sabanacentrocomovamos.org/wp-content/uploads/2016/04/Cartilla-Indicadores-EMUB2015.pdf>, 2015.
- [5] Velandia Durán, E.A. La movilidad en bicicleta como respuesta a la insostenibilidad del sector transporte. Realidad y desafíos en Bogotá. *Épsilon*, 11, Disponible en: <http://revistas.lasalle.edu.co/index.php/ep/article/view/1397/1274>, pp. 37-40, 2008.
- [6] Baéz, Manuel., *et al.* Introducción a Android. Madrid: E.M.E. Editorial©. 1 p.
- [7] López, Manuel. La historia del Android. En: unocero. [en línea]. (2014). [consultado 15 abril 2016]. Disponible en <https://www.unocero.com/2013/09/23/la-historia-de-android/>.
- [8] Blanco, Paco., *et al.*, Metodología de desarrollo ágil para sistemas móviles Introducción al desarrollo con Android y el iPhone. Madrid. Tesis (Doctorado en Ingeniería de Sistemas Telemáticos) Universidad Politécnica de Madrid. Facultad de ingeniería de Sistemas, p. 17, 2009.
- [9] Google play store. En Google Play. [en línea]. [consultado 1 jun. 2016]. Disponible en <https://play.google.com/store?hl=es>
- [10] Irpdevelop. En bici App. . [en línea]. [consultado 20 de Agosto de 2016], Disponible en: <https://www.facebook.com/enbiciApp>, 2016.
- [11] Vásquez, A. Me Voy en Bici App. [en línea]. [consultado 20 de Agosto de 2016], Disponible en: [https://www.facebook.com/Mevoyenbici/about/?entry\\_point=page\\_nav\\_about\\_item](https://www.facebook.com/Mevoyenbici/about/?entry_point=page_nav_about_item), 2014.
- [12] Wikicicleta Team. [en línea]. [consultado 20 de Agosto de 2016], Disponible en: <http://wikicicleta.com/>, 2015.
- [13] BikeCityGuide. BikeCityGuide. [en línea]. [consultado 20 de Agosto de 2016], Disponible en: <http://www.bikecitizens.net/>, 2014.
- [14] Ride the city. [en línea]. [consultado 10 de Agosto de 2016], Disponible en: <http://es.ridethecity.com/bogota>, 2013.
- [15] Bicimapa.Bicimapa. [en línea]. [consultado 10 de Agosto de 2016], Disponible en: <http://www.bicimapa.com/>, 2014.
- [16] Mejor En Bici®. [en línea]. [consultado 20 de Agosto de 2016], Disponible en: <http://www.mejorenbici.com/Nosotros>.
- [17] Sampieri, R., Collado, C., & Baptista, P. Metodología de la Investigación. México: Mc Graw - Hill Interamericana, 1991
- [18] Lohr, S. Muestreo: Diseño y Análisis. México D.F.: Ediciones Paraninfo, 2006.
- [19] Secretaria de Movilidad. Informe Especial 14: Ciclorutas Bogotá. (pág. 31). Bogotá: Universidad Nacional de Colombia, p. 31, 2013.
- [20] De Felipe, S. Peguese la rodadita! Bogotá pedalea en más de 20 colectivos urbanos de ciclistas. [en línea]. [consultado 05 de Septiembre de 2016], Disponible en: <https://www.civico.com>.
- [21] Django Project. *Documentation: Installing Geospatial libraries*. [en línea]. [consultado 10 de Agosto de 2016], Disponible en: <https://docs.djangoproject.com/es/1.10/ref/contrib/gis/install/geolibs/>, 2016.
- [22] PostgreSQL. (2016). *PostgreSQL 9.4.9 Documentation*. [en línea]. [consultado 01 de Agosto de 2016], Disponible en: ¿What is PostgreSQL?: <http://www.postgresql.org/es/documentacion>
- [23] PostGIS. (2016). *GEOS Released*. [en línea]. [consultado 12 de Agosto de 2016], Disponible en: <http://postgis.net/2005/07/04/geos-2-1-3-released/>

- [24] Steer Davies Gleave. *Encuesta de Movilidad para Bogotá*. Bogotá: Unión Temporal Steer Davis Gleave, 2011.
- [25] GDAL. (2016). *GDAL - Geospatial Data Abstraction*. [en línea]. [consultado 12 de Agosto de 2016], Disponible en: <http://www.gdal.org>