A MOBILE ARCHITECTURE FOR INTEGRATION OF SMARTPHONES WITH LBS FOR FLORA AND FAUNA INVENTORIES

UNA ARQUITECTURA MÓVIL PARA INTEGRACIÓN DE TELÉFONOS INTELIGENTES CON LBS PARA INVENTARIOS DE FLORA Y FAUNA

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ABSTRACT: Smartphones currently have a large number of sensors and more processing capacity, allowing greater integration of a mobile architecture supported by an external Location Based System. The following paper will contextualize the architecture in a nature inventory with a strong mobile component in the data collection on site. It will integrate additional technologies like GPS, QR Codes and map deployment through the LBS.

KEYWORDS: Geographical Information Systems, Location Based Services, Web Map Service, Mobile Computing, Software architecture, QR Code.

RESUMEN: Los teléfonos inteligentes cuentan actualmente con una gran cantidad de sensores y mayor capacidad de procesamiento, lo cual permite una mayor integración en una arquitectura móvil apoyada por un Sistema Basado en Localización externo. En el siguiente artículo se contextualizará la arquitectura en un inventario de fauna y flora con un fuerte componente móvil en la recolección de información en terreno. Se integrarán tecnologías adicionales como GPS, códigos QR y despliegue de mapas a través del LBS.

PALABRAS CLAVE: Sistemas de Información Geográfica, Sistemas Basados en Localización, Servicio de Mapas Web, Computación Móvil, Arquitectura de Software, códigos QR.

1. INTRODUCTION

Geographical Information Systems (GIS) have become significantly more important in the information society to manage, manipulate, synthesize and apply knowledge to the solution of environmental problems. The use of geoinformation on the web is increasing every day, providing services that allow users to search for datasets satisfying certain requirements [1] To disseminate geoinformation through Spatial Data Infrastructure (SDI) and to support the well-known concept of “collect data once, use it many times”, it is important to generate information automatically. Major initiatives in Geographical Information System (GIS) and interoperability are solving new problems by defining sets of standards and by specifying development interfaces [2].

The environmental issues that affect natural resources, require the support of ICT’s (information and communication technologies) which allow them to provide solutions based on new strategies, which facilitates the information’s integration with the objective of supporting people interested in improving their knowledge about the problem, and to propose improvement processes in order to carry out sustainable environmental management.

From this problem, the following question is proposed:

Is it possible to find a technological strategy that allows location and georeference cataloging, and quantification processes of flora and fauna, by using smartphones?

Mobile Computing is a term used to describe technologies that enable people to access network services anytime, anyplace, and anywhere. Ubiquitous computing and nomadic computing are synonymous with mobile computing [3].

This article summarizes the experience of specification, design and implementation of a prototype called ISFFA (Information System of Flora and Fauna) developed by the Pontifical Xavierian University along with the Colegio Corazonista both located in Bogota.

ISFFA's main objective is to catalogue and geographically label a significant sample of the different varieties of flora and fauna located in Bogota's savanna. The species information has been collected with smartphone using Android OS [4].

The system is compound of elements that make capturing information easier, like the sensors currently available in smartphones, in this case the camera and GPS [5]. For the storage, a centralized and georeferenced database with web access and SOAP [6] communication between mobile devices is used. The analysis processes are made through a geographical information system and generates an output for those interested, such as maps with the location of the flora and fauna, their descriptions, features and images for each one of the species.

For this case study, an area of about 8 hectares located in the north zone of Bogota was selected, which was populated with 54 flora species [7] and 28 fauna species [8]. The proposed architecture showed some advantages making the integration of these devices with the GIS a lot easier.

During the prototype's development, the use of sensors in an innovative way was emphasized, giving new usages to the camera as a QR code reader [9] and linking it with the GPS [10] in order to obtain the location of the information taken by the camera.

2. METODOLOGY

The system was created applying the lifecycle methodology of the saw tooth model created by Robert Rowen in 1990 [11]. The methodological phases used for the development are represented in Figure 1:

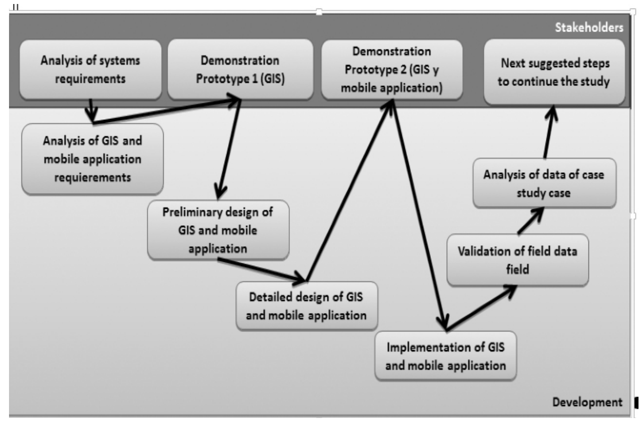

Figure 1. Life cycle saw tooth.

The phases mentioned above were supported by the teachers in charge of the Environmental Education Project (PRAE by its acronym in Spanish). From these phases the system's prototype was consolidated, and then aimed, mainly, towards the mobilization process for collecting information [12]. The mobilization process allows the data to be obtained in an agile way, reduces the information lost in the inventory process and increases the impact in the individual work performed by the participants in the process.

The collection of the information in the field is proposed in Figure 2:

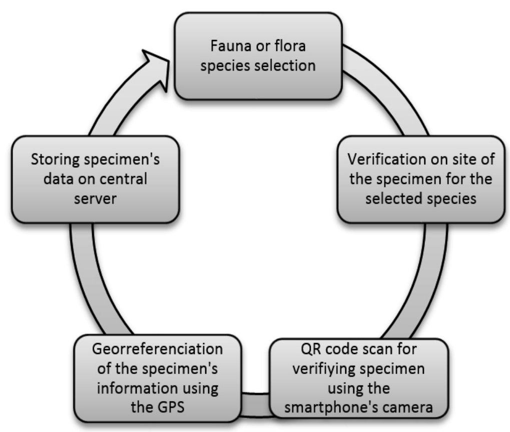

Figure 2. Cycle of collecting of data.

The information contained in the QR code [13] is presented in the following format:

Specimen identifier – Specimen name – Supplementary information.

An example of the coding is presented in Figure 3:

Figure 3. QR code of specimen labeling.

2343 – White and Red Acacia –commonly found in meadows closures. It usually exceeds 3 meters up to 8 meters high.

The QR codes are located in the flora specimens and in the fauna habitats with the objective of determining its location in the campus of the Colegio Corazonista in Bogotá.

The data stored in the system correspond to the information on the species of flora and fauna. For the flora species, the common name, the scientific name, description, usage, origin and habitat are storage. For the fauna species the feature in storage is the taxonomic classification: kingdom, phylum, subphylum, class, order, family, genus, species and its features. In the particular case of flora and fauna specimens the geographical location obtained by the GPS is stored.

The outputs shown by the system to the end-user are:

- Printout of flora and fauna species.
- Description of the species, photo and location map of the species within the campus of the school.
- Flora specimens general map with their description.
- Fauna specimens general map with their description.
- Flora and fauna specimens general map with their description.

3. PROPOSED ARCHITECTURE

The architecture developed for this system is based on the architecture aimed for mobile application services [14] which distributes the responsibilities of data processing and storage within the mobile device and the central server, employing for this purpose the philosophy of the Service Oriented Architecture (SOA) [6].

For the architecture's design, some current technological restrictions were taken into account such as the limited resources of processing, memory and battery life, reliability and data transfer through a mobile network.[15]

For the purpose of reducing the impact of these restrictions, some algorithms that require low processing, low memory storage and low hard drive storage have been implemented**.** For that reason the architecture uses the SOAP [16] protocol to improve the interoperability between mobile devices and central server. The architecture shown in Figure 4 is focused, mainly, for an application to Geographic Information System [6] and Location-based service [17]:

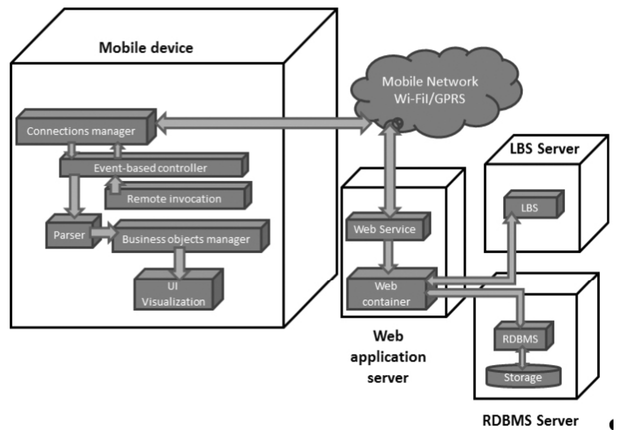

Figure 4. Mobile architecture proposed.

In the proposed architecture, there is a great emphasis in the architectural design of the mobile application due to the importance that the capture of the information directly in the field has, because it is important to quantify the specimens and obtain their localization. The collected data was optimized for the storage and processing resources of the device, and also to make an adequate use of the data network (WiFi or GPRS).

The software architecture designed for the mobile device focuses its functions on the event-based controller. This component manages the actions triggered by the mobile device user and the actions and data collected by the sensors. The component is tightly related with Remote Invocation component and Connections Manager component due to the way that the remote methods in the web service are invoked.

The application server responsibility is to manage the Java objects [18], the database information, and the Google Web Map Service. In this node the Java objects were allocated in Enterprise JavaBean (EJB) containers [18] and the web pages were generated with Google Web Map Server using the API [19] to load georeferenced data about the species of flora and fauna.

4. RESULTS

The following sets, model the system logic, obtained from the system:

$$A = \{x: x \text{ is an specie of } Fauna\} \quad (1)$$

$$A_E = \{x: x \text{ is an specimen of } Fauna\} \quad (2)$$

$$A_E \subseteq A \quad (3)$$

$$B = \{x: x \text{ is an specie of } Flora\} \quad (4)$$

$$B_E = \{x: x \text{ is an specimen of } Flora\} \quad (5)$$

$$B_E \subseteq B \quad (6)$$

$$A_E \cap B_E = \emptyset \quad (7)$$

$$A \cap B = \emptyset \quad (8)$$

As shown in the equations (7) and (8) the sets are mutually exclusive between species. There is a relationship of inclusion with the specimens of each species through equations (3) and (6) because the specimen is part of a species of flora or fauna.

On the other hand, the sets bounds are defined in the Venn diagram shown in Figure 5. In this diagram the inclusion relationship between the specimens, in green, and species, in dark blue, is visible, the specimens are part of one species and one species has a set of specimens.

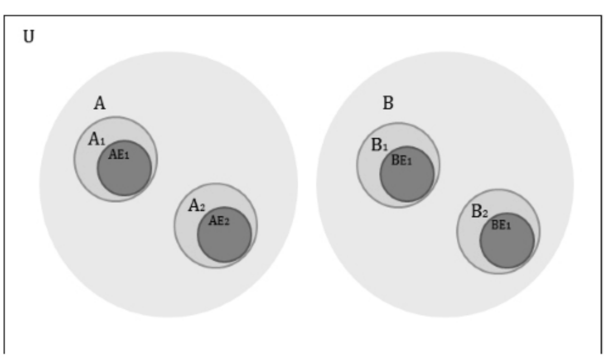

Figure 5. Venn diagram showing data sets and inclusion relationship.

As a result of the prototype, for the proof of concept 5 representative flora and fauna species for the school were characterized:

Table 1. Flora and fauna species characterized.

Flora species	Fauna species
Acacia Blanca y Roja	Cacatúa
Pino Limón	Gansos – Ocas
Rosa	

The species are located in different places of the school which were georeferenced with the process previously described. Below there is a satellite image from Google Maps [19] with the markers and the resultant information of the process:

Figure 6. Example of a general map of specimens of flora and fauna.

The blue markers represent flora specimens and the red markers, fauna specimens. The average accuracy recorded for all the specimens is 11.25 meters. This accuracy is justified because the Samsung Galaxy Young's GPS has a maximum accuracy of 5.44 meters [20] and weather factors, such as cloudiness, decrease the accuracy.

For the experience described before the following software and hardware tools were used:

Software:
IDE NetBeans 6.9.1, Eclipse Indigo JEE, Android SDK for Windows, MySQL Server for Windows, QRDroid for Android, Google Picassa, Google Maps API.

Hardware:
Mobile Devices: Samsung Galaxy Young
Network Client: Intel Core 2 Duo 2.4 GHz. RAM memory: 4 Gb. OS: Windows 7 Professional, Network interface controller: 10/100 Mbps.

Server: Intel Xeon 1.4 GHz Quad Core, RAM memory: 4 Gb. OS: Windows 7 Enterprise, Network interface controller: 100/1000 Mbps.

5. VALIDATION OF RESULTS

For the results validation, the general map of flora and fauna specimens with the obtained results was used in order to verify that the map data matched the existing results. An example of the validation performed of the species in field was carried out as follows:

Figure 7. Validation of the species in the field.

As a part of the validation of results, it is important to identify the components of data quality, because the micro level components and macro level components are useful to characterize data quality factors [21]. In this way, the micro level components evaluated were:

5.1. Positional Accuracy

The positional accuracy is the expected deviance in the geographic location of an object in the position [22]. In the case of the data collected by the system, the mean of the accuracy measure of the GPS is 11.11 meters and the standard deviation is 2.24 meters. This statistics shows that the accuracy measure is similar along all data and the value of the accuracy depends of the GPS sensor, that is located in Samsung Galaxy Young due to each model of smartphone has a different embedded GPS sensor [20].

5.2. Attribute Accuracy

The attributes used in the data model to store the flora and fauna species were: Species name, scientific name, kingdom, phylum, subphylum, class, gender, description. All the attributes are continuous because each attribute can take different values limited by the length of the field. The main categories used to catalog the data were: fauna specimens and flora specimens in the data model.

On the other hand, the macro level components evaluated were:

5.4. Time

The time is an important attribute of the georeferenced information because it allows the study of the historical changes of the data. [23]. The units of time are reported in the timestamp of the data capture provided by the mobile device.

5.5. Lineage

The data model includes the traceability of the transactions that happened in the past with the purpose of storing the past states and changes of the inventory's specimens. The lineage of the items is important to store historic data using metadata [24]. An important part of the metadata was obtained from the timestamp in order to study the historical evolution of flora and fauna specimens.

As a result of the validation process, it was found that the information processed by the system is reliable, because it matches the actual location and characteristics of the different elements of the inventory.

6. CONCLUSIONS

The integration of the different systems involved (LBS and mobile devices) with the proposed architecture, the obtained results, and the validation of results shows the feasibility to perform similar implementations in open spaces such as crops or natural parks, in which some quantification tools and a species catalogue located in the area, are required.

The innovative use of smartphones in the system as an instrument for collecting data is a tool of great importance since it simplifies the tasks of accounting, geographical referencing and information accessing of the species. Accomplishing these tasks directly in the field helps improving the labors of upgrading, maintaining and retrieving information in a more dynamic and direct way by end-users.

The software architecture proposed can easily integrate more types of components. Moreover, the architecture shows great advantages because there is a low cost solution compared to traditional forms of conducting flora and fauna inventories. From the computational viewpoint, we showed a scalable architecture that allows multiple devices to collect information using mobile heterogeneous hardware platforms that use the Android operating system.

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