# Tracking System using Location-Based Services Technology


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## Abstract

*Available ubiquitous networks that make use of small mobile devices like PDA and cellular phones, offer varied possibility of use by new generation application softwares. These applications utilize the available networks and devices to help users in their daily activities in different geographical areas. These set of applications constitute location based services and combine Geographic Information Systems (GIS), wireless network, and Global Positioning System (GPS) architecture or Global System for Mobile communications (GSM) networks for positioning processes. With Location Based Services, mobile devices can provide features grouped in different categories such as tracking, emergency and navigation. We built a solution that uses GPS and GSM infrastructures to help local custom officers in goods tracking around a defined area.*

*This paper is aimed at giving a description of an architecture that uses ubiquitous network to localize a vehicle, and GIS techniques to plot goods' positions on a map, and then generate a bitmap as a snapshot of the map status at a given moment. Our description focuses on the manipulation of mapping and imaging concepts to represent dynamically a moving truck's path.*


## 1. Introduction

With the passing of time, the personal computers' physical appearance has become smaller, and so have handsets and PDA (Personal Digital Assistant) as a result of the miniaturization of electronic components. The success of mobile telecommunication since the 90s has oriented new technological developments towards the production of sophisticated handsets. The use of an intelligent handset anywhere and anytime brings to light many more options on its use and the question: "How can I have information about my location and my environment?". The answer to this question is a merger of the GIS and Telecommunication systems; it is a new set of applications that provide location based services.

Location based services can be group into three categories:

- real time navigation and tracking features,
- emergency,
- Localized marketing, advertising and billing.

In Location based systems, maps are generated using information on given geographical coordinates, with the maps exported as picture that can be viewed on a user's handset or a server screen.

The setting up of a platform for localized geo-services requires knowledge on both mobile technologies and information on Geographical Information Systems and the development of software for establishments.

SOFT-TECH Int. has as one of its products cargo-tracking software which was developed for used by institutions such as the Cameroon Customs Department.

We will now present our work done on the software to add new modules that provide new features into the cargo tracking system such as:

- Real time determination of a cargo's position;
- Cartographic, visual, and interactive exploitation of the geographical information describing the legal route and actual route used by the cargo in transit.
- *Provide a GSM interface for data consultation via SMS message using mobile communication equipment.).*

We finally implemented a java distributed application.

## 2. Location Base service Overview

### 2.1. Generic Architecture

Geo-localized systems constitute a new domain incorporating users of Geographical information Systems (GIS) as well as wireless telecommunication companies. Initially, GIS was conceived to function on powerful configurations, in order to execute search on specific land locations and to generate possible access routes. The architecture of geo-localization combines GIS functionalities, and support media, to access information from distantly located databases.

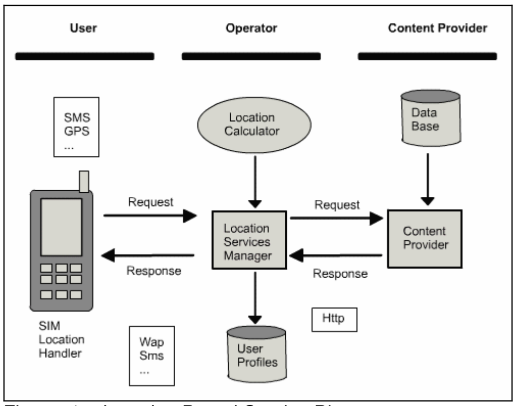

Figure. 1. Location Based Service Players

From a macroscopic point of view, the generic architecture of the system composes of three components [1]:

- Users: the subscriber, represented by a mobile handset that incorporates a module for identification and localization (SIM: Subscriber Identity Module). This device permits an interaction with the system (sending of SMS messages, vocal signals, and use of WAP page) and some geographical positions calculation.
- Network operator: this represents the network infrastructure of a telecommunication operator and comprises a Location Calculator and Location Service Manager. The wireless network supports the transmission of data, while the location calculator uses GSM cells or compatible handsets to localize users. The Location Service Manager authenticates users.
- Content Provider: This constitutes the provisional base of geo-localization services. They manage the POI (Points of Interest) and map data.

## 2.2. Services

The geo-location based services can be broken down into four categories. These include information, aid, fleets follow-up and operator [2]:

**2.2.1. Information Services.** This groups services is available to users who request information on their geographical position relative to given locations: the nearest open pharmacy; a suitable route to a specific destination, etc.

**2.2.2. Aid Services.** Emergency calls and no-income generating services offered by the operator. This is different from other aid services which require a subscription. This type of services permits a precise localization of a particular object, say a stolen vehicle.

**2.2.3. Fleets follow-up Services.** It concerns movement of materials or individuals thereby allowing for optimization of point deliveries at precise destinations. The service permits real time follow-up and route tracking of packets.

Location technology is base on positioning technology, geographic information system, and location management function.

## 2.3. Positioning Technology

There are a variety of positioning solutions available. They can be broken into three groups.

- Network-based methods: cell of origin or Cell-ID methods, Measure of the arrival angle, and the time difference of arrival.
- Handset-based methods: OTD (Observed Time Difference), GPS Positioning.
- Hybrid methods of positioning which combine the properties of the first two groups.

These different solutions offer a compromise between the speed of determination of user's localization and the accuracy of the expected result. Depending on the application, accuracy might be more important than speed or vice versa. For example, provision of an application permitting a user to search for the closest open restaurant with the aid of a cell phone. It would be sufficient to use the longitude and latitude coordinates of the cell from where he is calling; and then quickly return the list of the restaurants corresponding to the request, instead of waiting for GPS readings on localization before processing the data on the list of restaurants.

Because of the large surfaces covered by mobile operators' networks, and the GSM compatibility with most available mobile devices on the market, location based services use GSM network as main means communication [3].

## 2.4. Spatial analysis server

A spatial analysis server is composed of a set of libraries of software components executing a search and sorting out of cartographic data from a database [4]. It requires specialized business logic and an access to cartographic data via an interface such as GML (Geographic Markup Language). Three types of data bases exist useful for the storage of the cartographic data: pure relational, object, Hybrid databases.

In order to better understand the working of a spatial analysis server, it is necessary to have a good base on the structure of digital maps.

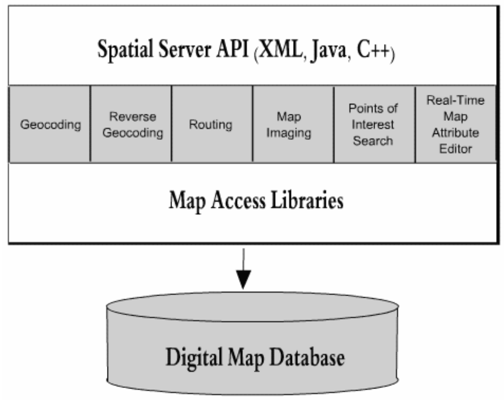


Figure. 2. Spatial analysis server components

**2.4.1. Digital Mapping.** A digital card has as objective capture all underlying details of one or several geographical phenomena and to make them accessible via a dynamic query of data, a spatial analysis, and return a suitable diagram. A numeric card transports two types of information: the nature of the different objects present and the site of each of them. This leads to the concept of the geographical world which is more like a composition of entities endowed with attributes, properties, and a site on a card according to a precise coordinate system. This approach is typical of the Vectorial model of data description, where the entities are represented on primitive geometry entailing the point, the line, and the polygon.

A second approach consist of some specific attributes (such as the altitude) continually subjected to variations that are interpreted by a mathematical functions (notably differential numeric functions), which in some cases divide the geographical space into discreet units which constitute the base of raster maps. There exist two types of cartographic data format types [4]:

- Vectorial format, exploited to describe the relations between entities of the real world,
- Raster format, most often built using a regular grid and exploited to describe aerial views or satellite pictures.

Most map databases include some basic POIs (Points Of Interest) such as airports, train stations, parks, schools, and others. There are various search types that make it easier for an application to quickly find the right POI for a user. POIs and mobile localization devices are exploited via geo-coding and reverse geo-coding operations.

**2.4.2. GeoCoding and Reverse GeoCoding.** A location based service which functions at city level must be able to pinpoint an address on a map. This operation is known as geographical coding. GeoCoding is the process of determining a latitude/longitude coordinates from a given address.

Reverse geoCoding is the process of identifying the nearest road segment in a map database given a latitude and longitude pair. This latitude and longitude data would typically be generated by the mobile device's positioning system. Once the nearest road segment is available, it is possible to process driving or walking direction requests or POI lookups.

**2.4.3. Routing.** A routing engine calculates the optimum path between an origin and destination, subject to certain criteria. Common criteria include "use freeways", "avoid freeway", or "fewest turns". The most common algorithm for calculating routes is based on A* (pronounced A-star) algorithm developed in the artificial intelligence community [5].

The most common routing problems include shortest path, traveling salesman, single depot – multiple vehicle, and multiple vehicle – multiple depot routing. The simplest and most often used is the shortest path between two points.

## 3. Tracking system Model

"TRACK LBS SUPPORT" is a location based services module we intend to integrate in the preexisting system "Track – Transit Control Manager". The main objective of "Track – Transit Control Manager" is to help custom officers in their task of following up goods which are on transit over the Cameroonian territory. This concerns custom products declared under the "D15 Regime".

### 3.1. Problematic

"TRACK - Transit Control Manager" aims to store, process and publish data on cargos declared under the "D15 Regime". Basically, "D15 Regime" concerns cargo that arrives at Douala port (in Cameroon), and destined to be consumed in another country. Thus cargos under "D15 Regime" are exempted from all customs taxes.

The processing of this type of cargo consists of the following steps:

**3.1.1. Cargo arrival at Port.** Cargo entry into Cameroonian territory is generally through the sea port of Douala. The importer declares the cargo under "D15 Regime" after depositing a bank guarantee.

**3.1.2. Legal route definition.** "TRACK - Transit Control Manager" publishes a title of transit, and records the established legal route, as well as the maximum cargo delivery time.

**3.1.3. Cargo monitoring.** The legal path includes some custom stop points for cargo registry. precising cargo passage time. Each custom station has incorporated in it a 'TRACKPOST', which is a client system of "TRACK - Transit Control Manager". It furnishes the central system with updates on cargo tracking data.

**3.1.4. End of journey.** When the cargo arrives at its destination; the country's custom services send a certificate of clearance to the Cameroonian custom office responsible for issuing transit titles. This information of clearance is recorded in "TRACK - Transit Control Manager" who does some reconciliation between the D15 concerned, transit's titles and the certificates of clearance partners in order to establish if the banking guaranty can now be released.

## 3.2. System requirements

TRACK - LBS SUPPORT aims to extend the working of the existing system to use a location based services infrastructure for cargo localization.

The novelty in the progress of the customs activities mentioned above is marked by the following elements.

**3.2.1. Location device assignment.** As the cargo is sealed by the custom, loaded onto a transportation vehicle, a positioning device (such as GPS) is attached to it. The transporter makes sure the attached device is not damaged in the course of journey.

**3.2.2. Truck tracking data exploitation.** "TRACK - LBS SUPPORT" collects the geographical position calculated by the localization device, which permits the custom service to:

- have a graphical representation on Cameroon's map of the legal route followed by the cargo in transit,
- get the real time position of a cargo in transit,
- follow up the graphical displacement of a cargo in transit,

Added system features include access via cell phone and SMS services by a custom agent who can be able to:

- Have the position of the cargo in transit (proximity address),
- Know the time a cargo in transit passes through a determined point,
- Know the last custom station crossed by the cargo,
- Know if a cargo has already reached a given custom point or not.

Finally, at the end of the transit, the localization device is returned to the Cameroonian custom house before the release of the caution.

## 3.3. Logical and physical architecture

**3.3.1. System Architecture.** Track LBS supports a combination of client/server application and some mobile localization devices. Custom stations are linked to the head quarter through a wireless network. The server's main role is to receipt geographical coordinates of each cargo which are registered under "D15 Regime". A graphical representation of each truck's route is store in the system's database. Users can connect to the server using a client application, to view information about particular cargo.

The mobile device use for localization should contain two a SIM cards and should be GPS capable.

- The GPS module calculates and stores the position of the truck at a given time.
- After a precise period of time, a set of determining coordinate are send to the server via the GSM network [3].

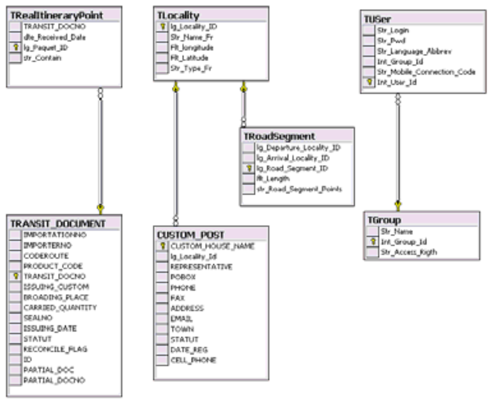


Figure. 3. System relational database's main tables

**3.3.2. Geographic Map model.** Our implemented model contents main items like database's tables such as:

- TRANSIT_DOCUMENT: Stores the titles of transit.
- CUSTOM_POST: References to available custom stations.
- TRealItineraryPoint: Stores geographical serial points which describe the route of a truck (legal or actual).

- TLocality: References to specific POI such as cities, villages, and road junctions.
- TRoadSegment: Represents a road segment that joins two distinct localities.
- TGroup: Stores available users' groups.
- TUser: Stores users' profiles.

## 4. Prototype Implementation

### 4.1. Technical choices

A GIS application needs to have an access to standard map formats. Some available API (Application Programming Interface) samples include:

- MapObjects Java Edition version 2.0, developed by ESRI (Environmental Systems Research Institute),
- MapXtreme of the publisher of the famous GIS software: MapInfo.
- OpenMap: under the free license.

After many comparative tests with these APIs, we retains MapObjects library version 2.0. The first set of map data incorporate in the system was incorporated in three vectorial map layers which contain respectively, Cameroonian geographical information such as :

- cities and villages
- provinces
- main roads and secondary roads

Our map data information composed of shapefiles extracted from the project CARP (Central African Regional Program heart the Environment) and the geographical database "World Resource Institute's 1995 Africa Data Sampler".

Shapefile format are supported by some GIS software such as ArcEditor and ArcGIS Desktop, edited by ESRI.

Track – LBS support was developing with JAVA, used to gain access to the system's relational database, implemented under Microsoft SQL Server 2000.

### 4.2. Server application Prototype description

The developed prototype can be presented considering its main user interfaces. They intend to perform task like:

- Give an overview on all available information related to a giving cargo under "D15 Regime".
- Provide a cartographic representation of the legal and actual route associated to a cargo.
- Permit real-time map data edition through a useful administration interface.

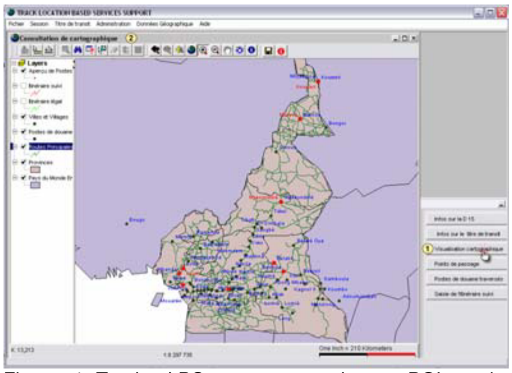

Figure. 4. Track - LBS support map viewer : POIs such as custom station (Red Point) and cities (Black Point)

Before opening a working session, users need to authenticate themselves by entering a valid login name/password pair.

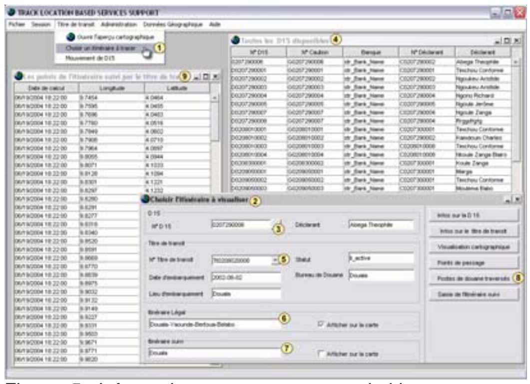

Figure. 5. Information on a customs transit title

A cargo to track is selected using the menu:
"Transit Title > Choose Cargo to track" (1).

Existing transit's titles are list after specifying the associate D15, using the button "listing all available D15 Cargo" (3) from the window form named "choice a cargo to track" (2).

The form "listing of all D15 Cargo" (4) permits the selection of an available D15 Cargo. This form provides meaningful information about a D15 Cargo, such as its number, the bank where the caution was placed, and the name of the importer.

Once the "D15 Cargo" is specified, a transit's title can be selected (5). The system then calculates and shows a more textual description of the associated route: legal route to follow (6) and actual route itinerary (7)

Each textual representation is made up of POI (custom stations, towns or villages) which are included in the route.

In other words, user can view detailed geographical coordinate registered for the current cargo routing (9). In the same way a map generation can be shown after a click on the button "View Actual Route on a Map" (8).

Geographical data are shown on a vectorial map which is a superposition of four layers:

- Cameroonian towns and villages. These are represented with names displayed with blue font.
- Custom stations. They are represented with names displayed with red font.
- Cameroonian provinces.
- Available world countries.

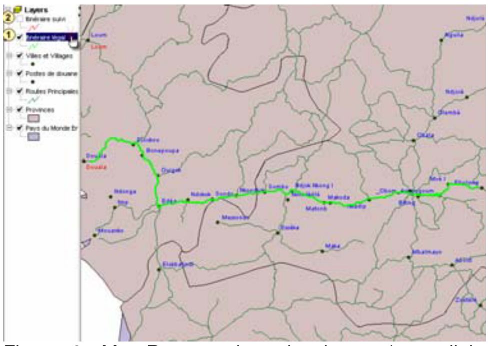

Figure. 6. Map Representing a legal route (green light line).

Users can customize map appearance by clicking on the map that supports each of them: legal route (1), or actual route (2). Thus legal and actual route can be shown independently or simultaneously; depending on the visibility of the associated layer.

To keep map database up-to-date, "TRACK – LBS support" has a form available for real-time map database edition. With this feature, a map database administrator can add / modified / deleted some POIs such as custom stations, cities (towns and village), and road segments. Thus, the generated map will be closer to the field reality.

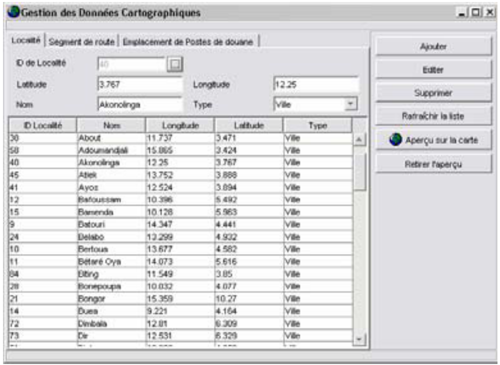


Figure 7 : Track-LBS support Real-time map database editor

## 5. Conclusion

This work is aimed at realizing and implementing a model of a tracking system using location base technology. For more accuracy of localization, our mobile location device uses a GPS Reading. Some features such as an access to the service via SMS gateway must be integrated by now. J2EE architecture has been chosen to have a robust server side application.

## 6. References

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