# Development of Real-time Tracking & Log Management System using Free and Open Source Software

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## Abstract

*This research shows a new approach for Location Based Services (LBS) to provide GPS track log management through Open Source Software and Open Standards compliant prototype system. Recently, the performance of low cost GPS receivers has greatly improved due to better GPS chips, enhanced receiver functionality and SBAS (Satellite Based Augmentation System). However, GPS signal are degraded in "urban canyons" and under forest canopy nearby. This research shows the effective way to minimize the GPS signal errors through developed quality filtering by PDOP (Positional Dilution of Precision) and GPS positioning status, and road network based map-matching functionality. The prototype system also provides POI (Point of Interest) management functionality which can store POI in DBMS with multi-media data such as picture, movie, sound, and memo and can be synchronized with GPS track point automatically based on the common date and time attributes. Therefore, the user does not be required to carry special devices for field survey, for example, GPS enabled cell-phone or camera. This research aimed to achieve an effective framework for field survey in order to support the route and POI management using the developed GPS track log management functionality. The system also offers participatory framework for building POI with multiple users together through the Internet. Moreover, the research will scope to expand real-time data collection functionality for future ubiquitous environment. The research outcome could contribute to various location-based data collection subjects which include real-time targets.*

## 1. Introduction

One of the recent developments in geospatial technologies is the ubiquity of location information. Especially, the emergence of GPS-enabled cell phone and mobile devices has facilitated mass marketing of Location Based Services (LBS). For example, navigation service, geo-tagged contents, Volunteered Geographic Information and tracking of assets and personnel. Integration of GPS and GIS is also effective for fleet management, logistics, emergency medical services, rescue and relief. Access to such LBS requires the use of customized devices or service-supported cell phones. Presently, it is difficult to develop or tailor LBS that could meet a wide variety of application scenarios and user needs. There is a need to implement a framework, wherein LBS and other geospatial services could interoperate more easily and effectively.

Although the performance of low cost GPS receivers have greatly improved due to better GPS chips, enhanced receiver functionality and SBAS (Satellite Based Augmentation System). GPS signal are degraded in "urban canyons" and under forest canopy nearby. In the prototype system, GPS signal errors are minimized using map-matching functionality which is implemented using PostGIS and quality filtering for GPS data using PDOP (Positional Dilution of Precision) and GPS positioning status data, e.g. 2D, 3D fix mode or no fix, available on the server. Further, the prototype system provides better interoperability between LBS and Geospatial applications by implementing workflow using Open Geospatial Standards.

## 2. Prototype System

### 2.1 System Architecture and Feature

Prototype system for real-time GPS tracking and log management was developed using FOSS4G tools. The workflow for prototype system can be demarcated into 3 components (Figure 1). First is tracking component that includes GPS enabled target. Second is the server component that provides data processing, archiving and geospatial services. Third is the client component for viewing GPS location and the track log.

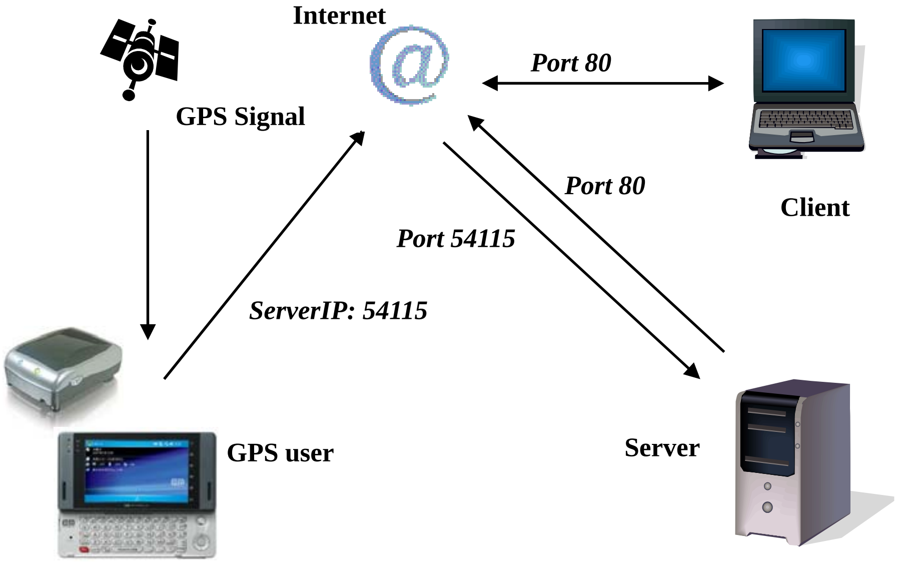


Figure 1. System Overview

### 2.2 GPS Tracking Component

PDA (Windows Mobile 5 in SHARP EM-ONE) with some of low cost Bluetooth GPS receivers, e.g. Hicom 406BT-C, Wintec G-Rays2, i-Blue GPS logger and GlobalSat TR-102 Personal Tracker were used for the experiments in Japan (CDMA) and India (GSM). Japanese cell-phone use CDMA system (W-CDMA and CDMA2000). On the other hand, most of countries use GSM. In this research, the experiment in Japan used HSDPA (High Speed Downlink Packet Access) connection of W-CDMA. HSDPA allows the user to have 14.4Mbps wireless connection at the maximum speed. In addition, WiMAX (Worldwide Interoperability for Microwave Access) service is going to be started from the year of 2009 in Japan.

Figure 2 shows the system architecture of GPS tracking component. Java program was developed in order to retrieve raw GPS data as NMEA (National Marine Electronics Association) format such as RMC, GGA and GSA from a GPS receiver. In addition, Mysaifu JVM (http://www2s.biglobe.ne.jp/~dat/java/project/jvm/index_en.html) was used for executing Java program under Windows Mobile. To send GPS data to the server, a socket program was implemented in the Java program. The Java program carries out to retrieve GPS raw data and sends to the server regularly such as every 5 seconds or 10 seconds，it depends on user's needs.

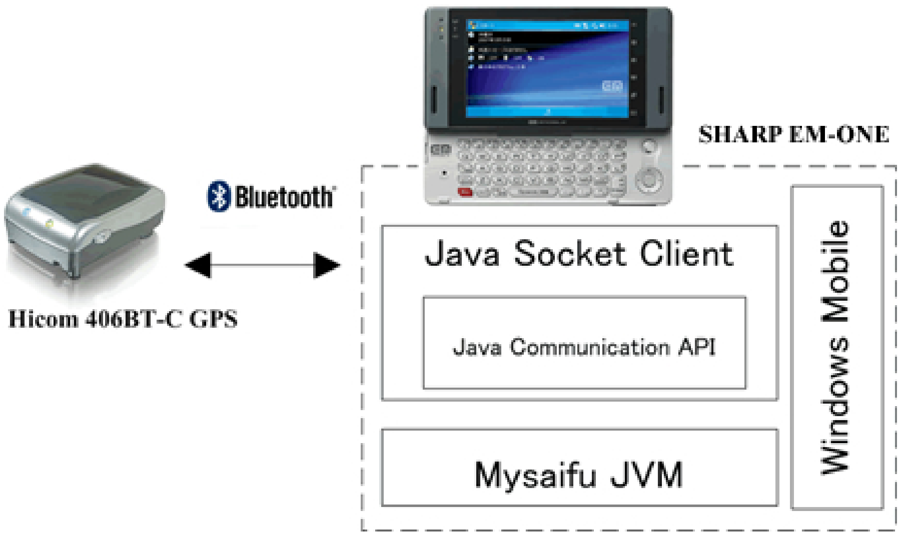


Figure 2. System Architecture of GPS Tracking Component

### 2.3 Server Component

The server component was implemented on Linux platform using Apache, PHP, Java, PostgreSQL and PostGIS in order to store GPS data from tracking component and display the current position of GPS target on the web map (Figure 3). OpenLayers was adopted for the web mapping viewer application. OpenLayers is one of the most active Open Source web mapping application and it can show interactive map using AJAX and overlay with a lot of data types, e.g. Google Maps, Yahoo Maps, WMS, WFS, GeoRSS, KML, etc. In the prototype system, Google Maps (vector and satellite maps) are used as a background layer. And a road layer (Orkney 2007 Data Pack) can be overlaid through WMS connection.

Data from the tracking component in raw NMEA (National Marine Electronics Association) format are parsed to each of information (Table 1) and archived in PostgreSQL DBMS. For real-time tracking, the client component accesses the OpenLayers site in which layer auto-refresh functionality with GeoRSS was implemented or uses Google Earth for 3D enabled tracking which accesses server-generated KML in real-time.

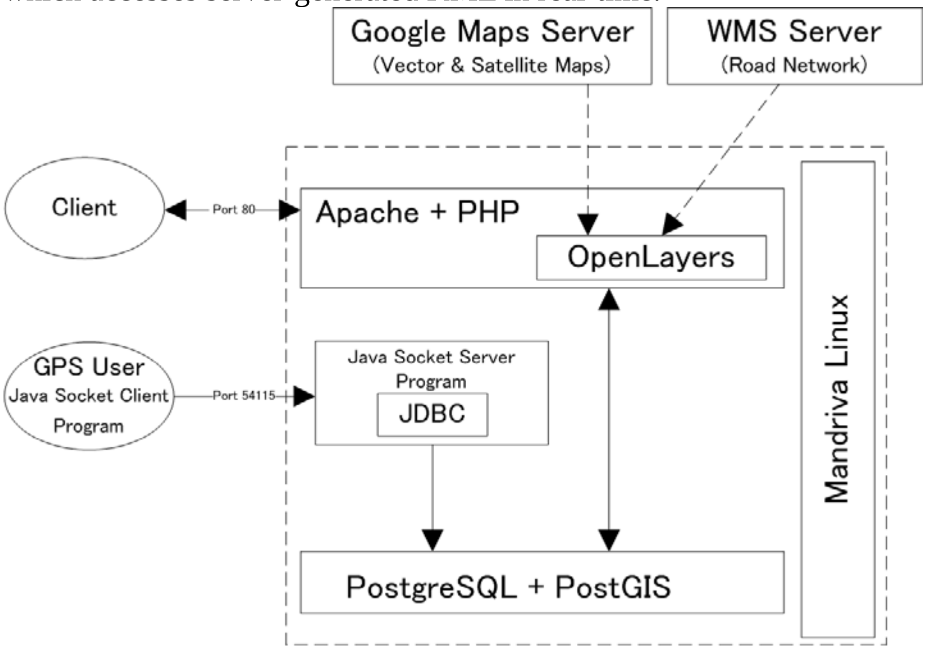


Figure 3. System Architecture of Server Component

Table 1. Archiving GPS Data

| Name | Description | NMEA |
|---|---|---|
| Date | Date in UTC | RMC |
| Time | Time in UTC | RMC |
| Direction | Direction of travel | RMC |
| Speed | Speed in km/h | RMC |
| Longitude | Longitude | GGA |
| Latitude | Latitude | GGA |
| Altitude | Estimated altitude above the sea | GGA |
| Number of Satellite | Number of active satellite which is used for calculation | GGA |
| PDOP | Positional Dilution of Precision | GSA |
| VDOP | Vertical Dilution of Precision | GSA |
| HDOP | Horizontal Dilution of Precision | GSA |
| Checksum | Checksum of each NMEA date | GSA |
| GPS Mode | Positioning status: 2D, 3D or no fix | GSA |
| IP Address | IP address of GPS tracking component | none |

To overlay with Google Maps, the projection had to be set Mercator projection (EPSG 900913) and needed to write the following parameter for Proj (in /PATH_TO_PROJ/proj/epsg), an Open Source cartographic projections library.

*<900913> +proj=merc +a=6378137 +b=6378137 +lat_ts=0.0 +lon_0=0.0 +x_0=0.0 +y_0=0 +k=1.0 +units=m +nadgrids=@null +wktext +no_defs <>*

To convert the current projection into EPSG:900913, the below command was incorporated in the system.

*$proj +init="epsg:900913" TEXTFILE*

Map-matching functionality was implemented using PostGIS. When GPS signal is weak or lost, a current position tends to be indicated far from actual position. Map-matching functionality is to snap an wrong position onto the nearest road line.

The PostGIS command (find_nearest_link_within_distance) which was developed by Orkney Inc. (Japan) retrieves the nearest line node from a given point within designated area is shown as below,

```
=# select AsText(the_geom) from osaka_roads
where gid = (select * from
  find_nearest_link_within_distance
('POINT($proj_result)',100,'osaka_roads') );
```

The following PostGIS command returns the nearest position on the nearest line node which is retrieved by the above commands.

```
=# select AsText
(line_interpolate_point
        (LineStringFromText('LINESTRING($data)'), line_locate_point
        (LineStringFromText('LINESTRING($data)',900913),
        PointFromText('POINT($proj_result)', 900913) )    )) ;
```

These PostGIS and Proj commands were written in Java program and JDBC (Java Data Base Connectivity) was used for an interface to PostgreSQL. The java program opens a server socket to receive GPS data which comes from GPS user and executes above commands and converts NMEA format to GeoRSS and KML for displaying in OpenLayers and Google Earth.

## 2.4 Client Component

Client uses web-browser or Google Earth to view GPS current location. OpenLayers provides displaying GPS location at real-time and interactive map operations through web browser (Figure 4). The prototype system allows user to use Google Earth. Google Earth can display real-time GPS location at 3D angle, fly through view and also with 3D buildings using KML file.

In client component, track log management functionality was developed (Figure 5). The user can query and display the track log on-the-fly by date, time interval between, IP address of GPS user PDOP and GPS positioning status, e.g. 2D, 3D fix or no fix mode on the web map.


Figure 4. Real-time GPS Location View using OpenLayers


Figure 5. Track Log Search Interface using OpenLayers

OpenLayers interface can display GPS raw points and map-matched points and lines based on road network data in accordance with searched result. Furthermore, the result points (Raw GPS points) can be exported as several formats such as KML and GPX formats for further use on other GIS applications. Google Earth 3D viewer functionality was also implemented in the log search interface using Google Earth API.

The prototype system provides POI management functionality and synchronizes POI and GPS track log based on the common date and time attributes. Figure 6 shows the POI marker and the image in a popup box. In the POI management functionality, the user can upload geo-tagged picture as Exif format or non geo-tagged picture by inputting the meta-information manually. Further, the user can edit or delete the uploaded data through the POI management web interfaces.


Figure 6. Displaying POI

Track log statistic functionality was also implemented to indicate the number of log points per day and hour at real-time using PHP/SWF Charts.

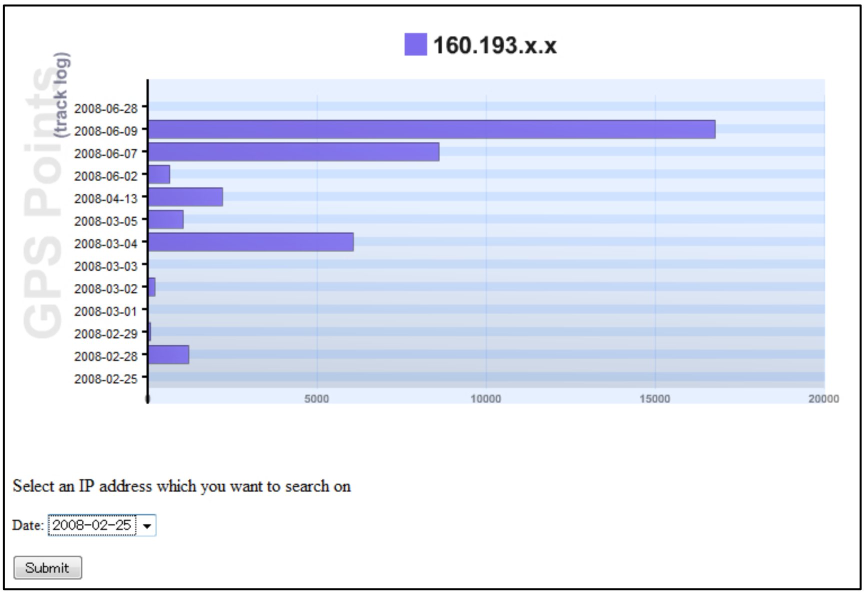


Figure 7. Real-time Track Log Statistics using PHP/SWF Charts

## 4. Conclusion

Along with recent LBS related developments, systems for Volunteered Geographic Information or user-generated contents services, for example, OpenStreetMap, Wikimapia have been incrementally developed and such geographical contents were rapidly increased by volunteers all over the world. The user-generated data can be used freely under Creative Commons license. VGI system can greatly help in developing Spatial Data Infrastructure (SDI) and it is useful in the poor coverage area of SDI to make geospatial infra data available, especially in developing nations or under emergency situation which needs the latest information after natural catastrophe such as terrible cyclone disaster in Myanmar in 2008.

In this research, the prototype system for GPS track log management was developed using FOSS4G tools. The prototype system also provides POI (Point of Interest) management functionality which can store POI in DBMS with multi-media data such as picture, movie, sound, and memo and can be synchronized with GPS track point automatically based on the common date and time attributes. This research achieved an effective framework for field survey in order to support the route and POI management. The system also offers participatory framework for building POI with multiple users together through the Internet. Moreover, the system focused on expanding to real-time data collection functionality for future ubiquitous environment. The system supports real-time and non real-time tracking targets using low cost GPS receiver or data logger and tested under both GSM and CDMA wireless network.

The research outcome could contribute to various location-based data collection subjects such as OpenStreetMap or other VGI, User Generated Contents services.

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