

# Web GIS to Identify the Problematic Mobile Signal Clusters

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## ABSTRACT

Mobile communications has become one of the fastest growing sectors in the world today. With the technological advancement, mobile communication has subjected to many upgrades such as 2G, 3G, 4G. The question of “Does a customer get the expected capabilities from it?” is not answered yet. Even though, the subscribers of all operators pay almost equal charges per minute, most of the time, they do not get the real benefit from the service. At the moment there is no any location based system to capture the availability of signal receiving levels (specially 3G and 4G signal for Dongles), when a customer sit in front of the marketing person, asking to provide a new connection. What most of the customers do is to use the equipment for few days and return them with a complaint of malfunction in case of signal unavailability. In this study geostatistical analysis was carried out by the method of Inverse distance weighting and the interpolated maps were generated using ArcMap 10. Maps were uploaded to the map server, with standard color ramp. Thereby, the network users can get a better idea about the variation of mobile signal receiving level in a particular location. The developed web based GIS (Geographic Information Systems) system provides the capability of accessing the mobile signal levels remotely in an online manner prior to dealing with a particular customer. Analysis of receiving signal level variation helps to find clusters which have low signal levels than expected. Also, further investigation can be carried out to determine the frequently changing network clusters against a relevant time domain.

## Keywords

Geostatistical analysis, Mobile drive test, Mobile networks, Signal receiving level, Web GIS

## 1. INTRODUCTION AND OBJECTIVE

Mobile signals are not in the range of visible spectrum which cannot be observed by the naked eye. Therefore people cannot understand how these mobile signals behave under different conditions making the users struggle when a signal interruption occurs. Visualization and prediction of these signals will provide a remarkable assistance for the people living in a technologically advanced era like the present [1].

Mobile signals transmit in the form of Electro Magnetic (EM) radiation. Therefore, the wave properties such as reflection, refraction, diffraction, interference are applicable for mobile signals also [2]. But the mobile subscribers won't get the expected quality of service even when they reside just close by the base transceiver station [3].

This generates a vast amount of problems to the mobile operators with high a customer disappointment. Background

noise, poor signal receiving level and call interruption during traveling are a few of them [3]. Maintaining error free networks with higher number of subscribers and an expected data rates with a better quality have become a challenging task for all most all the mobile operators.

In this study, the mobile signal receiving level of 2G, networks has been considered. Mobile signal receiving level basically depends on the distance to the base transceiver station location which transmits the mobile signal.

But EM wave propagation properties and geographical surface variation make this process very difficult to be predicted properly [3] [4]. Geostatistical analysis with mobile signal receiving level data which is taken from an existing mobile network will provide a reliable analysis for mobile signal receiving level distribution. Visualization in the sense of general color ramp makes it easy to understand about the mobile signal strengths in a precise manner [4]. Google maps base map layer provides a better understanding about the location information of the areas with malfunctioning mobile signal distributions [5].

## Objective

Providing a platform to identify and analyze the mobile network signal distributions which is available in an area of interest. The web based architecture provides an easy remote access to the developed system through the internet. Necessity of a thorough knowledge to analyze and identify the mobile signal level distributions has been minimized to a very lower level by the introduction of this automated system. Up to date coverage information which is provided by the system has increased the quality and the efficiency of decision making.

Most of the time subscribers suffer because of the unavailability of network services from place to place in their busy day today life making them disturbed with poor mobile network services.

But, the proposed system will guarantee a better quality of mobile network service making the customers to build a positive attitude towards the mobile network services. The GIS based web system displays, mobile signal receiving levels with the standard color ramp. Poor receiving level clusters and no service locations are highlighted using different colors helping the user to identify the problematic signal clusters. This will help to optimize network errors for better quality of service.

## 2. MATERIALS AND METHODOLOGY

### 2.1 Materials

#### 2.1.1 Open Layers

Open Layers is completely free, Open Source JavaScript, released under the 2-clause BSD License (also known as the FreeBSD). It is capable of displaying map tiles and markers loaded from a source map service [5].

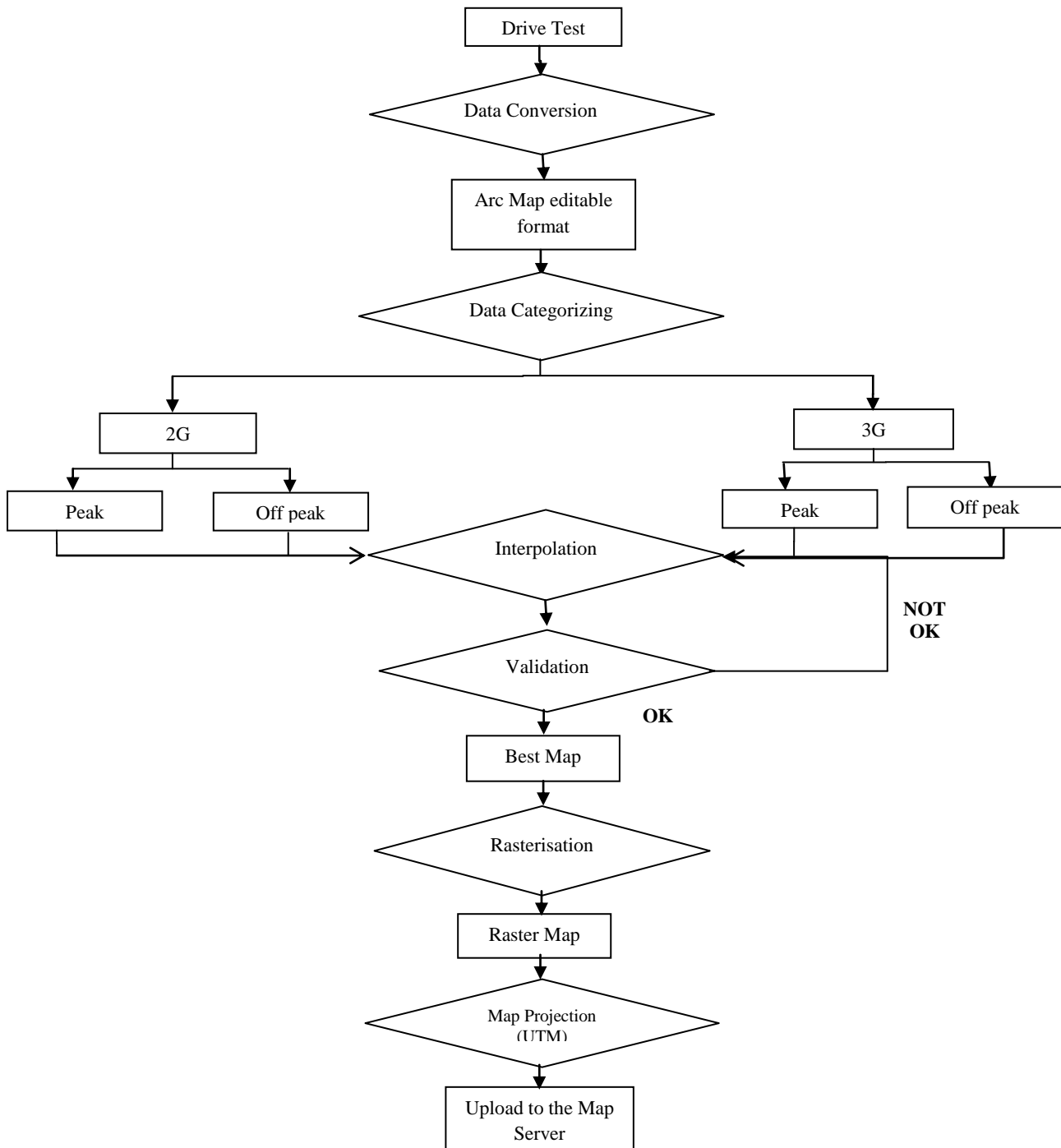
### 2.1.2 MS4W Map server

MS4W stands for Map Server for Windows. This is free and open source software package. It allows all levels of map

server users to quickly install a working environment for map server development on Windows. Packing and distributing map server applications can be done using MS4W environment [6].

### 2.1.3 Web client frame work

An open source web client framework at OSGEO which was used to implement the web interface.



**Figure 1: Architecture of the system**

Core of this program was written in JavaScript and HTML. It runs on web servers such as Apache, IIS, and Nginx [7].

#### 2.1.4 Apache Web server

Apache is an open-source HTTP server, available basically for the two operating systems UNIX and Windows NT. It provides a secure, an efficient and an extensible server that provides HTTP services in sync with the current HTTP standards [8].

#### 2.1.5 My SQL

My SQL is a relational data base management system which is used for adding, removing and modifying information in a particular database [9].

### 2.2 Methodology

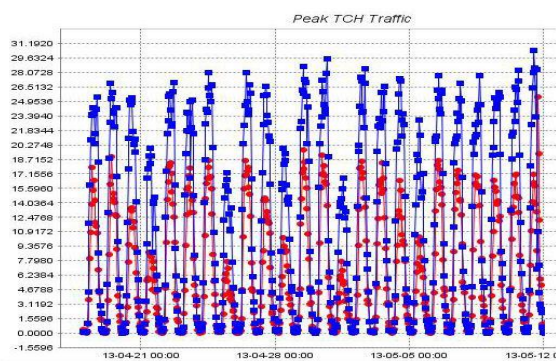
#### 2.2.1 Drive Test

Mobile signal monitoring process is simply known as drive test [10]. In this process monitoring equipment both hardware and software were implement inside a motor vehicle . Ericsson TEMP 9.0 software was used in recording mobile signal receiving level and an air interface monitoring phone was connected to the laptop to get input in units of dBm [11]. Bluetooth GPS with a better accuracy is used to record the mobile signal receiving level with its spatial location in WGS84 coordinates.

#### 2.2.2 Architecture of the System

Preliminary study was carried out to understand the network traffic of one whole day (24 h). After analyzing the Base Transceiver Station (BTS) traffic of 24 hour period, the analysis was divided into two parts. That is peak traffic (PT) time and off peak traffic (OPT) time. By analyzing the 24 hour period, generally two peak hours were observed. So, the drive test time was scheduled according to a predefined time period for PT and OPT. Average value of PT and average value of OPT were analyzed separately. The mobile signal receiving level obviously has a higher value near the base transceiver stations. Therefore, the GPS coordinates of these BTS locations were captured by a hand held GPS device.

It helps to determine the optimum path for the drive test to investigate the problematic clusters.

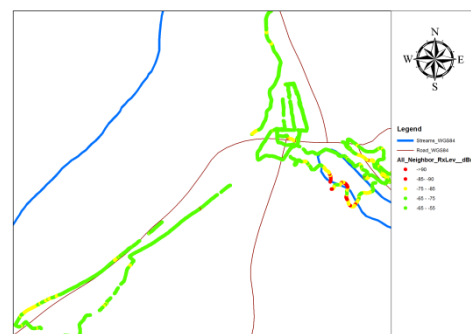


**Figure 2: Plot of Peak network traffic Vs. Time**

Network monitoring process was done for both 2G and 3G mobile networks. Recording relevant mobile signal receiving levels within a relevant time period (peak and off peak hours) is important. Therefore, simultaneous monitoring was carried out using two laptops independently. Drive test track was decided according to the city traffic plan. It helps to record data by traveling a minimum distance while covering a large area at once.

Recorded log files were exported and converted in to tabular format which can be retrieved using Microsoft excel [12]. To prepare the coverage maps files, relevant mobile signal receiving levels and their spatial location longitude and latitude coordinates data was extracted. All the tabular files were inserted to the MySQL database server and a further classification was examined. Data was categorized in to four main types of tables, 2G peak time period, 2G off-peak time period, 3G peak time period, 3G off peak time period. Then the 2G and the 3G mobile signal receiving levels of peak and off peak hours were loaded into separate databases and test points were extracted for the validation purposes. Analysis of the data and validation of the data files of 2G and 3G modes were imported in to personal geodatabase of ESRI ArcMap 10.

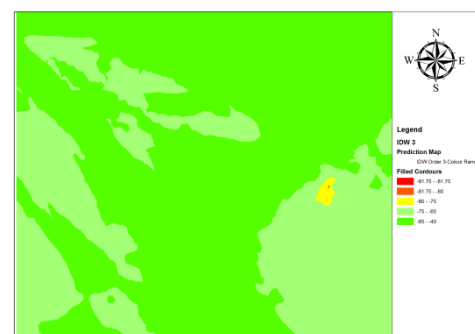
Overlay analysis was done with city road network which is depicted in Figure 5 for the categorization before the interpolation. Then the clusters were clarified with respect to the covered areas of drive test and tower population.



**Figure 3: Drive test tracks**

#### 2.2.3 Interpolation

A geostatistical interpolation was carried out for the determination of the best method to predict mobile signal receiving level. Geostatistical interpolation techniques of kriging and Inverse distance weighting were selected after the first stage of analysis. [4] [13] Selection of these two methods done by considering minimum standard deviation [14]. Different type of kriging patterns of ordinary kriging, simple kriging, universal kriging, indicator kriging were analyzed.



**Figure 4: Inverse distance weighting Interpolation**

Inverse distance weight with the powers of 1, 2, 3 with different neighboring limits were analyzed. Randomly extracted points were used to determine the accuracy of the validation. Method of interpolation was finalized in the final stage by considering the standard deviation value for each and every method mentioned [14]. Inverse distance weighting

method of power 3 results in the least value for sigma. Then Inverse distance weighting method was finalized as the geostatistical interpolation technique for the study.

### 2.2.4 Inverse distance weighting

A general form of finding an interpolated value  $Z$  at a location  $P$ , given values  $Z(1), \dots, Z(n)$  at distinct other locations  $P(1), \dots, P(n)$ , respectively. The interpolated value is a weighted average of the  $Z$ 's. It develops a sequence of numbers (the "weights")  $w(1), \dots, w(n)$  and forms

$$Z = \frac{[w(1) * Z(1) + \dots + w(n) * Z(n)]}{[w(1)+\dots+w(n)]} \quad [1]$$

Where,

$$w(i) = \frac{1}{Distance(P, P(i))^p} \quad [2]$$

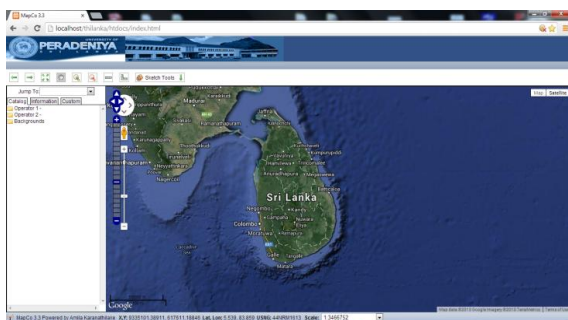
power 'p', is usually around 2, 3. The weights are inversely proportional to the power 'p' of the distances between the point of interpolation and the data locations [15].

Total interpolated map area was converted into the raster format. All the raster maps were saved in a map server. It gives quick access to webservice requests which is displayed on top of Google maps [6]. Interpolated maps show a smooth variation of mobile signal strengths in most of the places. But in some places sudden decrements can be observed. Then the raster 'tif' format was used to display the final map file on top of the base Google maps. Colors were assigned according to general color ramp which is used to display corresponding dBm units [11] [16] [17].

**Table 1: Mobile signal receiving level classification**

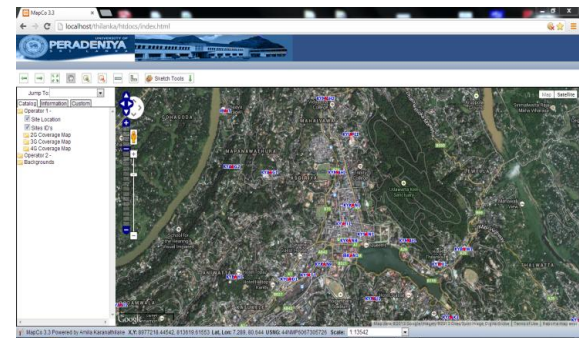
Signal Level Range(dBm)	Classification	Color
-120 to -95	Extremely Bad	Red
-95 to -85	Bad	Orange
-85 to -75	Average	Yellow
-75 to -65	Good	Light Green
-65 to -55	Very Good	Dark Green

## 3. RESULTS AND DISCUSSION



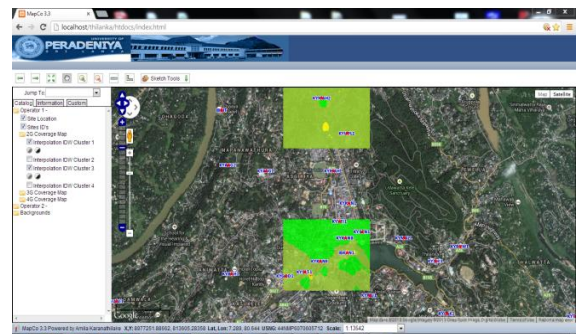
**Figure 5: Default Web interface**

Figure 5 depicts the default web interface of the map sever after login to the system. Left side of the interface contains the main folders which guide to map files. It contains Google maps as the base layer.



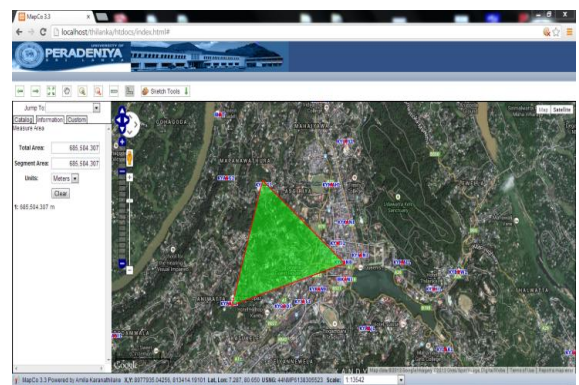
**Figure 6: BTS locations with site identification codes**

User can see the coordinates in Latitudes, Longitudes or Universal transverser marketer format at the bottom panel of the web interface. Search window with "Jump To" function give quick zoom to the Kandy city area as shown in Figure 6.



**Figure 7: Interpolation of Mobile signal receiving level (2G coverage map)**

By a single click of left panel, the system will display the 2G coverage cluster on top of Google base layer as shown in Figure 7. Transparency of the clusters can also be adjusted using the contrast tool. Users can find their locations and relevant mobile signal receiving levels easily by using the zoom in, zoom out and pan tools. Distance in between two BTS locations or distance to the problematic location can be measured using the measuring tool, provided. It may help to get an idea before adjusting the BTS parameters such as the antenna direction or tilt.



**Figure 8: Tool set for overlay analysis**

Transmission power limitations in between two BTS locations can be decided with the knowledge of the ground area in relevant units as shown in Figure 8. This can also be used to identify the locations which require new BTS for coverage enhancements.

#### 4. CONCLUSION

This system will help identifying the problematic mobile signal clusters so that, the network optimization engineers can directly focus their attention on these problematic places depending on the result generating from the proposed system. Subscriber locations and relevant receiving levels give clear understanding about usability of the equipment (specially 3G dongles) or commercial packages such as remote monitoring etc. System can be further developed to monitor all the mobile operators to provide a statistical measurement for their quality of service.

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