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Development of Drive Test Tool for GSM Networks

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Abstract: In wireless field, drive test is one of the major components which is carried out to measure the end customer/user radio signal level along with its quality. The measured level and quality is then analyzed to check whether the service targets are met or not. To perform a drive test for any wireless technology i.e. GSM or CDMA, we require a drive test tool. In this paper, a simple drive test tool is presented to check and monitor the quality of service of any GSM service provider e.g. Ufone, Mobilink, etc. The work is basically software but to make it functional, we have attached a mobile phone and a GPS receiver with it. The tool extracts geographical information (latitude and longitude) from the GPS receiver and the signal strength (RSSI) from the mobile phone. After receiving data from both the devices, it saves as well as displays the data continuously on a map. The GUI of this application is developed in C# environment. It has the standard Microsoft functionality. It displays the signal quality in any area using different color codes.

Keywords: GSM; network optimization; drive test; RSSI; C#.

1. INTRODUCTION

With the rapid growth of wireless industry, Global System for Mobile Communication (GSM) networks are growing at a high rate. In this milieu, high quality of service is a key for a service provider. To solve the network issues, service providers make use of a process called optimization. . The optimization process is shown in **(Fig. 1)** (Agilent Technologies, 2011). In network optimization many tools and techniques are used. Drive test is one of them.

Drive Test: In wireless field, drive test is the one of the key components which is carried out to measure the end customer/user radio signal level along with its quality. The measured level and quality is then evaluated to check whether the service targets are met or not. All the measurement is combined to indicate a few major performance indicators which are as mentioned below:

- Call Setup Success Rate
- Drop Call Rate
- Handover Success Rate
- Network Blocking and Congestion

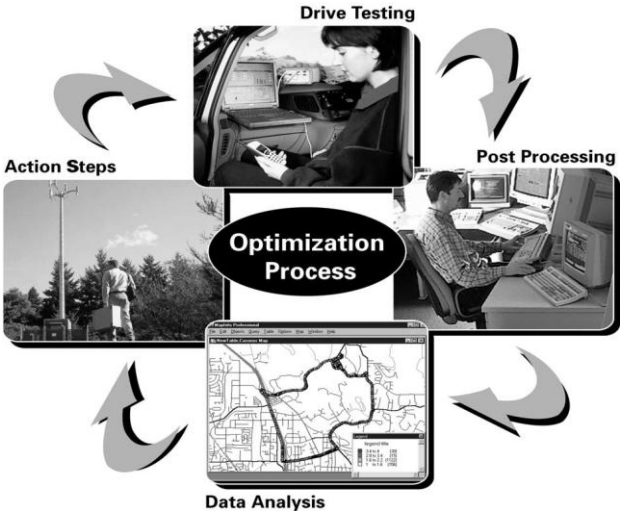

Fig. 1. The Optimization Process (Agilent Technologies, 2011)

The above mentioned Key Performance Indicators (KPIs) are extracted from the drive test tools with the help of the below mentioned graphical/tabular representations of the measured signal:

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- Radio Signal Level (Rx-Lev) dBm
- Radio Signal Quality (Rx-Qual)
- Frame Erasure Ratio (FER)
- Bit Error Ratio (BER)
- Time in Advance (TA)

Scope: The goal of this work is to develop tool for GSM networks that gives the signal strength of any service provider.

The scope of the work is to measure the signal strength from a mobile phone, coordinates from Global Positioning System (GPS) receiver and to transfer the data from the mobile phone and GPS receiver to the computer/laptop and display the results on a map.

Software is developed to make the interface between the GSM modem, GPS receiver and laptop.

The mobile phone captures the real time signal strength and transfers it to the Graphical User Interface (GUI) of the software. At the same time GPS receiver transfers the location coordinates of each sample point to the software GUI.

Each set of the radio signal level (Rx-Lev) and the coordinates will be plotted over a GUI, and a log file is then captured at the back end. The captured log file will be used at later stage to display the whole drive test radio signal level results on a map.

Developing Tool and Software: The output of this work is software. For developing software, we need a development tool and a developing environment.

While selecting a developing environment, our requirement was that it should be user friendly and easy to understand. Microsoft Windows developing environment is a very common one, so we preferred it as our developing environment.

Next decision was to select the development tool for developing the software. In windows environment, Microsoft Visual C# has the capability to create windows application very easily as compared to other tools. So the tool we used in this work was Microsoft Visual C#.

Available Drive Test Tools: Many companies like Ericsson, AIRCOM International, Radio Dynamics Corporation etc have developed their tools and provide services to cellular operators. We studied three professional drive test tools available in the market. The detail of these drives test tools and a little comparison of their features is done. Following are the names of the available drive test tools:

- ProScout™ GSM Drive Test System (Radyn, 2011)
- TEMS™ Drive Tester GSM/GPRS (Ascom, 2011)
- Xi GSM/EDGE (X-Tel Communications, 2011)

All the above tools have some common features which are main tasks for any drive test tool. These features are given below:

- Software driven
- RSSI Data Window
- Graph Window
- Map Window
- Audio alarms for safety during drive tests
- GPRS information
- Call Statistics and Handover Statistics

2. MATERIALS AND METHODS

Components

This section includes the information about the basic components which were required to build this tool. The components layout is shown in **(Fig. 2)**.

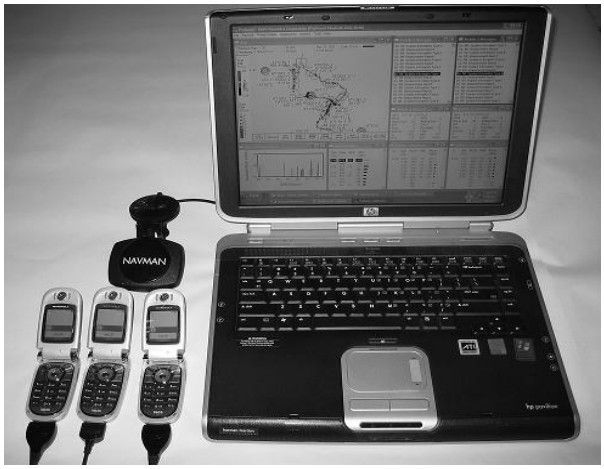

Fig. 2. Components Layout

GSM Modems: The first and the basic component of the tool is the GSM mobile phone (GSM modem). This is used to extract the Received Signal Strength Indication (RSSI) information. Modems offer remote access to machines in the field to eliminate unnecessary site visits and provide fast access to information in the machine (NowSMS, 2011). Modems are Attention (AT) command compatible at the serial interface to the machine and common between many modems (Developer's Home, 2011).

The AT command used in this work is "AT+CSQ". Execution command returns the RSSI **(Table 1)** from the mobile phone. Response is in the form +CSQ: RSSI.

Table 1. Signal Strength Indicator

0	*Equivalent to 0 bars displayed on the mobile phone*
1-5	Equivalent to 1 bars displayed on the mobile phone
6-10	Equivalent to 2 bars displayed on the mobile phone
11-15	Equivalent to 3 bars displayed on the mobile phone
16-20	Equivalent to 4 bars displayed on the mobile phone
21-31	Equivalent to 5 bars displayed on the mobile phone

Global Positioning System (GPS): The second component of the tool is the GPS receiver (SCIGN, 2011) (Garmin, 2011). This is used to determine the real time location during the drive test. It gives the information in the form of different strings, from which we can extract the location information. GPS signals are very weak inside the building/car. A serial interface is used in the work to extract the desired strings.

Geographic Information System (GIS): When we integrate the RSSI information with the GPS coordinates it becomes a geographic information system (GIS) system. A GIS captures, stores, analyzes, manages, and presents data that is linked to location. A GIS can be viewed in three ways (Wikipedia, 2011) (gis.com, 2011) The Database View **(Fig. 3)**, The Map View **(Fig. 4)** and The Model View **(Fig. 5)**. In this work the map view is used as a view of GIS system. This view is the most understandable view of GIS.

Fig. 3. The Database View

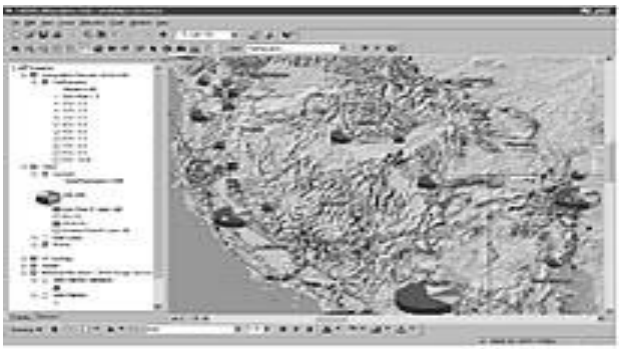

Fig. 4. The Map View

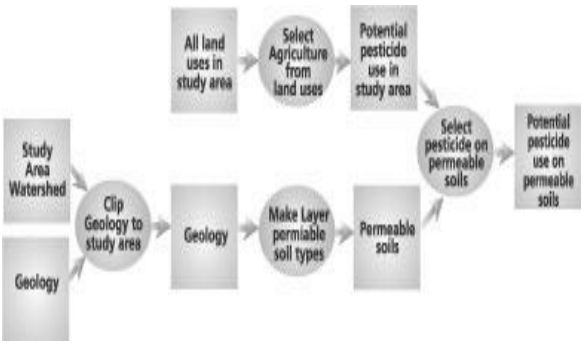

Fig. 5. The Model View

3. DISCUSSION

Design and Implementation

System Layout: (Fig. 6) shows the outlook of this work. Mobile phone takes the signals from the Base Transceiver Station (BTS) and sends RSSI to computer using AT commands. Same like mobile phone, GPS receiver provides the current latitude/longitude and sends it to computer, where the drive test tool captures data and plot it on the map.

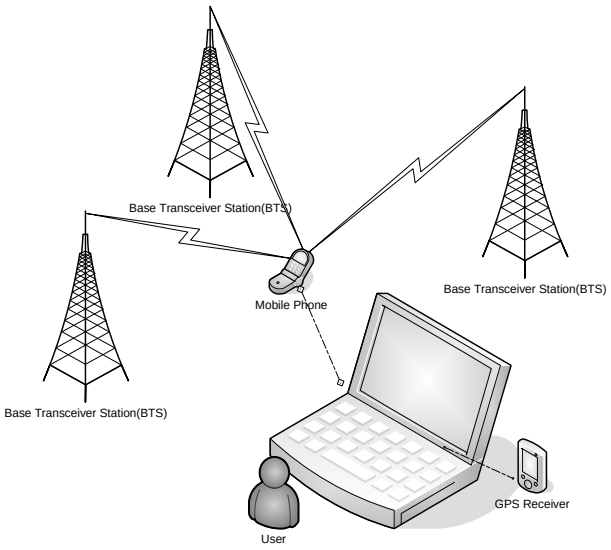

Fig. 6. System Layout

Data Flow Diagram (DFD): (Fig. 7) is the top level Data Flow Diagram (DFD) of this work. There are four major blocks of DFD. In data acquisition block, we acquire the required data i.e. RSSI from mobile phone and latitude/longitude from GPS receiver. In data processing block, we process and parse the acquired data. In data persistence block, we save the parsed data into log file. In data presentation block, we display the RSSI and latitude/longitude on the map at real time as well as from the saved log file. To implement these blocks, we divided our tasks into sub tasks and selected some tasks as our milestones.

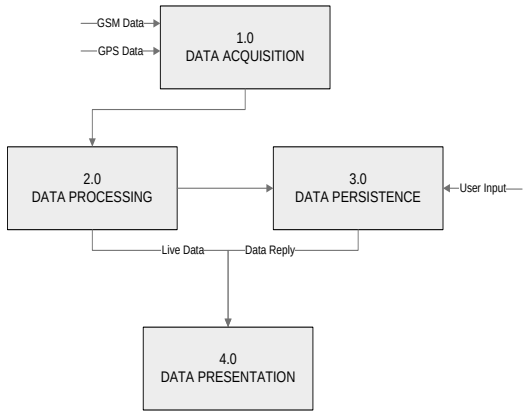

Fig. 7. Top Levels DFD

Data Acquisition: The data acquisition block of the top level DFD is divided into sub-blocks **(Fig. 8)**. After acquiring data from GPS receiver, the National Marine Electronics Association (NMEA) data strings are separated. In GSM request generation block, AT command is send to GSM modem. The mobile phone generates response and the acquired data of mobile phone is parsed. The NMEA data and RSSI are put into queue to process it further. Sub-tasks of data acquisition are given below:

Mobile Phone Selection: Mobile phone selection is the basic task to start the work. During the selection of a mobile phone several things were considered such as:

- COM/USB connectivity
- Easily available or not
- Supporting baud rate

For this purpose SonyEricsson K608i mobile is selected, which has all the above qualities.

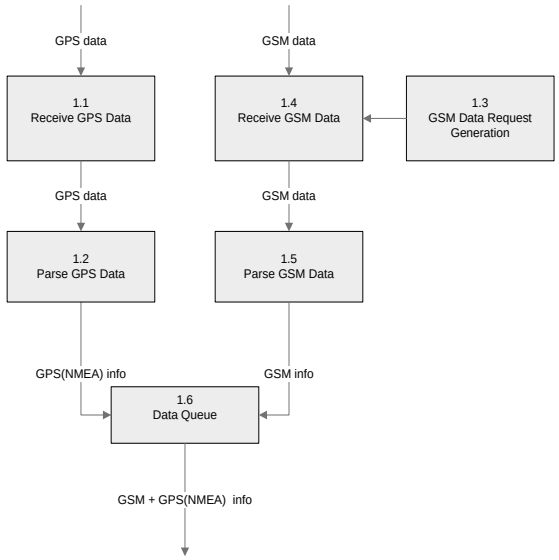

Fig. 8. Data Acquisition

Connecting a Mobile Phone: While connecting the mobile phone, the baud rate and port name of the serial port is set to connect the mobile phone with laptop.

Connecting a GPS Receiver: To transfer GPS data to map, we need a physical connection between the laptop and the GPS receiver. For communication between the two devices, serial cable and appropriate software is needed. To solve this problem, we need a simple piece of code by which we can connect GPS receiver to laptop. Following things are considered when we connect the GPS to laptop:

- Make sure GPS has a steady power source before transferring data to computer/laptop
- Plug the serial or USB cable into GPS receiver and laptop

Same like mobile phone, for the connectivity of GPS receiver, properties like baud rate and port name is set to connect GPS receiver with the laptop.

Data Collection: In data collection segment, two types of data have to be collected:

- GSM Data Collection — to collect the data from the mobile phone, we serially connect it to laptop. AT command is send to GSM modem. When mobile phone receives AT command, it sends back the values of RSSI at the same instant to the laptop.
- GPS Data Collection — to collect GPS data, we have to connect the GPS receiver, set the baud rate to 4800bps and capture the NMEA data strings at the serial port. We do not need to send any command to GPS receiver for accessing the NMEA data strings.

Data Processing: Data processing block of top level DFD is divided into many sub-blocks as shown in **(Fig. 9)**. From NMEA data, software finds the $GPGGA string and capture the latitude/longitude from it. The GSM data processing block separates out the RSSI value and converts the RSSI value into dBm. Different parts of data processing are explained below:

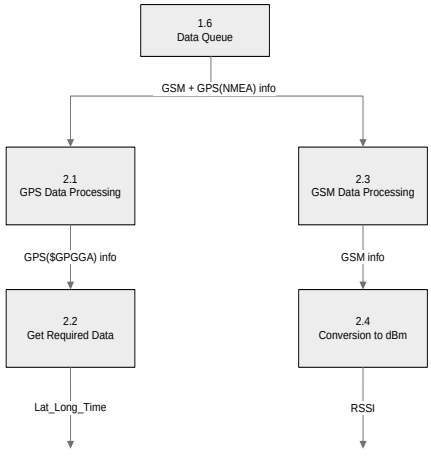

Fig. 9. Data Processing

Parsing GPS Data: To parse GPS data; code searches for Global Positioning System Fix Data ($GPGGA) string from the received data of GPS receiver. When the program finds the $GPGGA string, it parse the string further to get latitude and longitude using substring function. The latitude/longitude is in the form of degree, minute and second, while the desired data should be in float values.

Parsing Mobile Data: The received data is saved into a variable of integer type that converts into a string for further processing.

The mobile response is in the form +CSQ: 15, 99, where 15 is desired value of RSSI. Program separates out 15 using the function of substring and saves it into another string. The required values are then converted to dBm.

Log File Generation: When the drive test ends, log files are generated at the backend to preview the drive test later. Parsed values of mobile phone, GPS receiver and time and date are all concatenated and saved into a string. To write concatenated string into a text file, a text writer function is used. Three types of files are generated at the end of a drive test:

- User readable log file using ".txt" file type
- Play back mode log file using ".txt" file type
- MS Excel file using ".csv" file type

Data Persistence: The data persistence block **(Fig. 10)** saves the RSSI value, latitude/longitude and time/date into a log file which can be seen at any time.

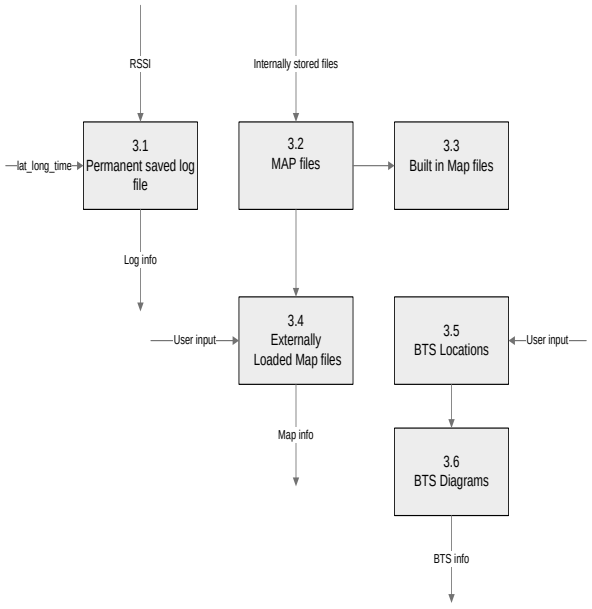

Fig. 10. Data Persistence

There are some internally loaded map files in the software and drive test can only be performed in those areas whose maps are loaded. To do the drive test outside these areas, external maps have to be loaded. Latitude/longitude of the BTS should be provided so that BTS's can be placed on the map.

If the user wants to replay the drive test, it simply plays the saved log file and previews it on map. Program simply reads the saved log file using text reader and sends RSSI and latitude/longitude to the function which plots the value on the map. All the log files can be viewed at any time.

Data Presentation: In data presentation block of top level DFD, a GUI is developed, which have standard Microsoft functionality **(Fig. 11)**. Map displays the signal quality along with its geographical coordinates (latitude and longitude) at real time as well as from saved log files.

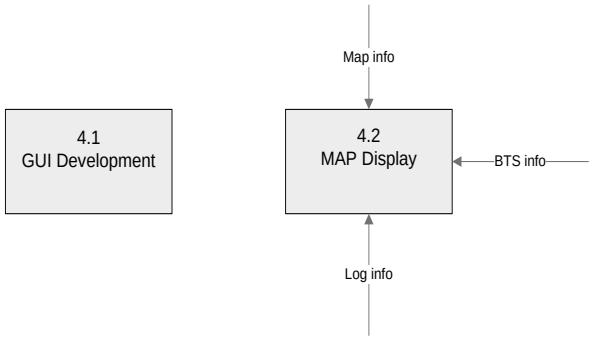

Fig. 11. Data Presentation

Function which plots the value on map takes the value of RSSI and latitude/longitude and calculates the pixel value using the built-in function of ActiveX. After calculating the value of pixels, program finds the desired value of latitude/longitude on the map. After finding the location, it draws the colored circle according to the legends defined.

The presentation part has two components defined below:

GUI development: GUI development is the last task of this work. GUI provides access to different menus/functions as shown in **(Fig. 12)**.

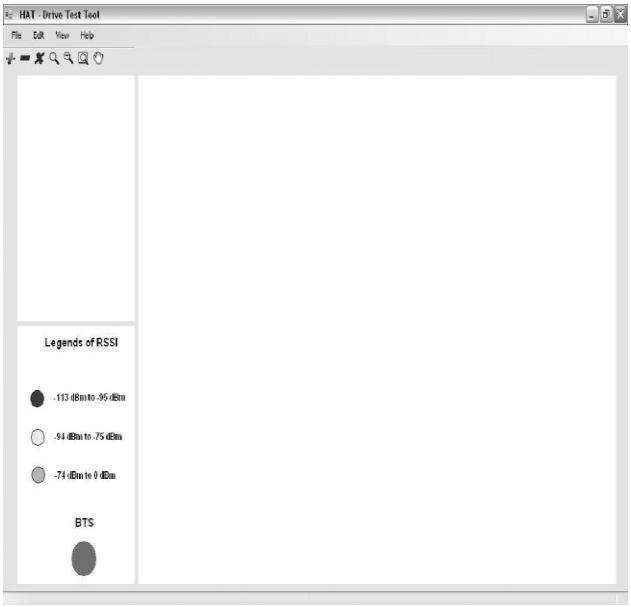

Fig. 12. GUI Development

Interface of map with GUI and embedding information to map: Real time plotting of RSSI values on map is shown in **(Fig. 13)**.

Fig. 13. Embedding information to map

4. CONCLUSION

This paper presented a simple drive test tool to check and monitor the quality of service of any GSM service provider. The main contribution of the work is the software to make the interface between the GSM modem, GPS receiver and laptop.

Following are some of the future enhancements of this work:

- Audio alarms for safety during drive test
- Support multiple phones simultaneously (two or three)
- Allows in-field, real time analysis
- User can do required analysis
- Graph window to analyze data
- Single or dual mobile window display
- Can import map files for any region in the world
- Call and handover statistics
- Quick and easy presentation views including GPRS information
- Near real time reporting
- Neighbor status display

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