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Performance Measurement of Mobile Data Networks

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ABSTRACT

Background: The article gives an overview of the implementation of a software "benchmarking" prototype for 2.5G 3G, 3.5G mobile data networks**. Objective:** This study was aimed evaluate the performance of multiple network variables for the three major telecommunications network operators in a sector of the City of Bogota (Colombia - South America). The methodology used included the design and development of software application and performance evaluation. **Results:** According to the measurements we conclude that the operator with better conditions for the provision of data service in the Bella Flor neighborhood is Movistar, with greater availability and stability, despite operating in the lower sector of the GPRS technology. **Conclusion:** The accuracy of the results found suggests that the designed product is a good choice for use by telecommunications operators as a tool to determine the quality of the signal received by end users.

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INTRODUCTION

There is currently a great lack of knowledge regarding coverage and actual performance of mobile data networks in certain areas of Colombia (Resolution, 2013), especially in depressed areas where people with the lowest incomes in our society live. This is affecting the way users access these technologies and is limiting the potential applications related to Information Technology and Communications (ITC) of social benefit that could be developed on these networks (Clint *et al*, 2014).

This project is proposed for one of the poorest neighborhoods of Bogota (Colombia), located in Ciudad Bolivar; It is framed within the Project Ciudad Bolivar Digital Locality, and involves the design and implementation of benchmarking software (comparison technique) for mapping coverage and measuring performance of 2.5G, 2.75G, 3G, 3.5G mobile data networks, which will allow to trace the performance (Martin, 2013) and coverage for the three mobile data operators (CLARO, TIGO and MOVISTAR) in this sector of the city, and to find out the actual state and potential of this technology to develop social welfare projects in the town.

Likewise, the tool would provide information to the operator about the places in which their level of coverage and/or access technology should be increased, and will help identify improvements or deterioration in the mobile data service for this particular area. Likewise, it seeks to provide information that will enable the development of social ICT applications in the lowest income areas, benefiting the community at large and making this technology a means to reduce the digital divide in our society (Martin, 2014).

MATERIALS AND METHODS

The software (SW) developed is called "benchmarking tool" (Fig. 1), and is basically a tool to collect performance information of a mobile network.

The performance of the wireless network is established by measuring the level of signal reception (RSSI), the network connection time (PDP context), the information transfer rate or better known as throughput, the type of network technology, and additionally the SW also records the geo-referenced position of the sample.

In its operational state the SW requests the 3.5G modems connected to the computer the status of each of the variables and also asks a Global Positioning System (GPS) the position in which the sample was taken (Lilian, 2006). Each of these measurements is repeated periodically depending on the number of samples that the user wishes to take; finally they are stored in a log file for later analysis.

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Fig. 1: General diagram of the designed Benchmark Tool application.

The user interface is the SW module that allows to configure and run the measurement of the variables (Madhusanka *et al*, 2011), and shown in Fig. 2.

This interface has two specific areas that are 'measurement setup' and 'measurement status display'. In the measurement setup, the user (Fig. 3) selects which variables they wish to measure as well as the number of measurement cycles. It is also possible to define the sample start and stop time.

Fig. 2: Benchmark tool user interface.

Fig. 3: Measurement Setup User Interface Section.

In the display area of the measurement status, the user can: observe the measurement status by means of a progress bar; the sample number (for example, if the user set up the device for ten samples the application will show the gradual progress from number one to number ten); determine the type of variable being measured at any time; Set whether the map view is performed using cache or obtained online from the selected map provider's servers, such as yahoo maps, google maps, google earth, among others; observe the making of a measurement record through marks on a map at runtime, and; export and import maps with markings.

Description Of The Test:

The tests were performed at the Bella Flor neighborhood in the Ciudad Bolivar locality (in the City of Bogotá), with the aim of measuring the performance of mobile data networks in their main points, as well as in their access roadways.

The equipment used in this test were 3 3.5G USB modems, a USB Hub, a Windows operated laptop, a GPS with serial interface for communication with the laptop and a DC/AC voltage inverter to power the laptop (Fig. 4). The software used was the free beta version of the Benchmark Tool. It should be noted that the application was used only academically and without any commercial purpose.

Fig. 4: Equipment used in the test.

Each 3.5G modem had a provisioned SIM card with an unlimited postpaid data plan of the following operators: Comcel, Tigo and Movistar. The connectivity of these plans was corroborated before starting the test in an area of high coverage (Fig. 5). Before making any measurement, the COMs ports of the USB cards in the software configuration file were configured, and the GPS was set to NMEA version 2.1 GSA (Joseph *et al*, 2011) in order for it to send the coordinate information through the serial port. Special care was taken to ensure that the position in which the cards and GPS were located allowed to have a clear and open view line between the equipment and the cellular network, as well as the GPS and the satellites from which the information is collected.

Fig. 5: GPS and USB Modem used in the test.

Prior to making the samples the connectivity of each card was verified in an optimal coverage area using the "Benchmarking Tool" software.

After having configured the equipment we move to the test area, which consisted of two main areas: the access road to the Bella Flor neighborhood through El Paraiso neighborhood, and the main roadway of the Bella Flor neighborhood, their secondary roadways and reference points such as the José María Vargas Vila District School.

The procedure consisted of going around these areas at a low speed (<10 km/h), to allow the software to take the greatest possible number of samples. The path followed including access roadways and the points where samples were obtained are shown in Fig. 6, image of the software developed and used for "Benchmark Tool" measurements.

Basically the first twenty samples correspond to measurements made on the access roadways, and the remaining thirty correspond to secondary roadways and measurements made nearby the José María Vargas Vila District School.

Fig. 6: Test path including access roadways.

RESULTS AND DISCUSSIONS

50 samples were obtained in the test. Each sample featured the following information for each of the operators:

• RSSI (Reception strength in dBm).
• Mobile Network Technology present at the time of measurement.
• Time the terminal takes to perform PDP context successfully.
• Downlink Throughput value in Kbps.
• Throughput for Uplink value in Kbps.
• Point of time at which the sample was taken
• Latitude in decimal coordinates,
• Longitude in decimal coordinates

The reception strength values in dBm for each of the operators are shown in Fig. 7.

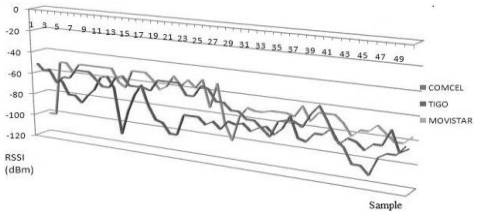

Fig. 7: Reception strength for the three operators.

Likewise, the average reception strength values for each of the operators was calculated and then graphed (Fig. 8).

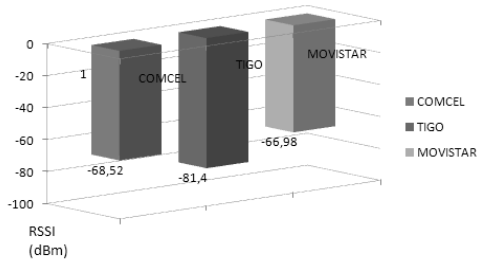

Fig. 8: Average reception strength value.

For each of the operators (Fig. 9, 10, 11) the network technology present during the followed path and its percentage against non-service measurements.

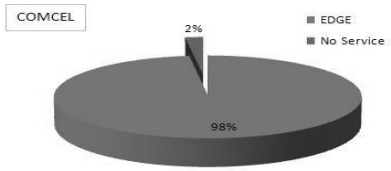

Fig. 9: Mobile access technology for Comcel.

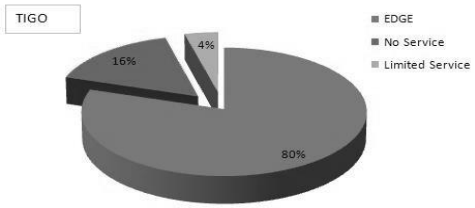

Fig. 10: Mobile access technology for Tigo.

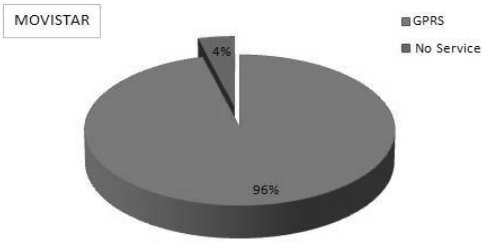

Fig. 11: Mobile access technology for Movistar.

The network connection time values for each of the operators are shown in Fig. 12, clarifying that the values at zero (0) time correspond to failed login attempts, and only those with different values to 0 (zero) were successful connections.

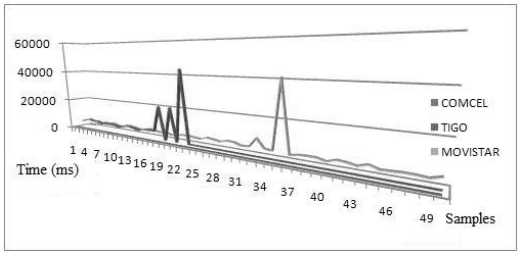

Fig. 12: Connection times for the three operators.

Similarly, the mean connection time values of each operator were obtained (Fig. 13); this is calculated taking into account only the values of successful connections as number of samples, in order to have a more accurate value of the average connection time for connections that were successful.

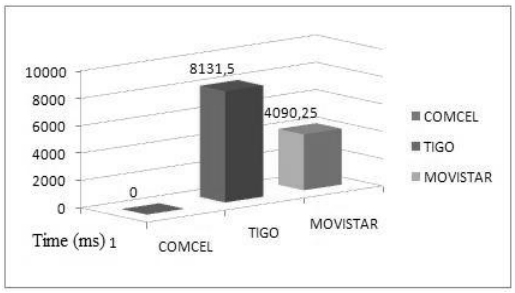

Fig. 13: Average connection time value.

Fig. 14 illustrates the percentage of successful connections for each of the operators, which is an important piece of data when measuring the performance of the data network.

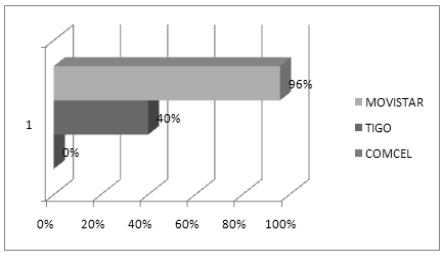

Fig. 14: Successful connections for each operator.

Throughput or the downlink transfer rate in Kbs for each of the operators is shown in Fig. 15, given that 0 (zero) values correspond to failed connections and thus there is no data transfer.

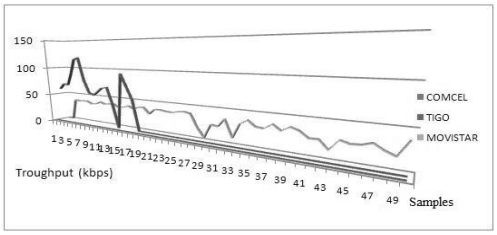

Fig 15: Successful connections of each operator.

The average transfer rate values for the three operators, taking into account only the values of successful connections as number of samples, for a more accurate value of the average transfer rate of actual connections is shown in Fig. 16.

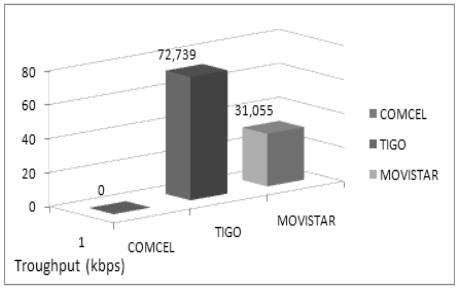

Fig. 16: Downlink throughput for the three operators.

Throughput or the uplink transfer rate in Kbs for each of the operators is shown in Fig 17, given that 0 (zero) values correspond to failed connections for which there is no data transfer.

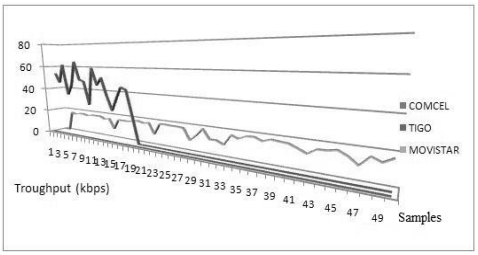

Fig. 17: Uplink throughput for the three operators.

The average transfer rates values for the three operators, taking into account only the values of successful connections as number of samples, to have a more accurate value of the average transfer rate for the actual connections is shown in Fig. 18.

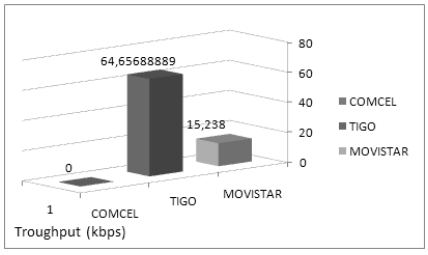

Fig. 18: Uplink throughput mean value.

Conclusions:

Operator Tigo showed better conditions than the other operators in areas nearby the antennas (Paraiso neighborhood), but RSSI levels decline rapidly in areas far away from the access roadways to the neighborhood, this is due to the frequency band at which Tigo operates, 1900 MHz, which has larger propagation losses compared to the 850MHz band.

Due to the results obtained with the tool, it is possible to present it to the Communications Regulation Commission (CRC) in order for it to provide support for making measurements of QoS in mobile networks.

Although the Bella Flor neighborhood is part of the urban area, it does not have any sectors with 3G services such as UMTS, and it only has second-generation technologies like EDGE and GPRS.

Transfer rates as reflected by the data recorded by the software were not consistent with what was theoretically stipulated in the standards for each technology like EDGE and GPRS.

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