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MONITORING CELLULAR NETWORKS PERFORMANCE VIA CROWD SOURCED IOT SYSTEM

MY OPERATOR COVERAGE (MOC)

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ABSTRACT: *The number of cellular mobile phone users has increased enormously worldwide over the last two decades. Consequently, the monitoring for the performance of the Mobile Network Operators (MNOs) in terms of network coverage and broadband signal strength has become vital for both of the MNOs and regulators. This monitoring helps telecommunications operators and regulators keeping the market playing fair and most beneficial for users. However, the adopted methodologies to facilitate this continuous monitoring process is still problematic regarding cost, effort, and reliability. This paper introduces My Operator Coverage (MOC) system that is using Internet of Things (IoT) concepts and tools to monitor the MNOs performance using a crowd sourced real-time methodology. MOC produces robust and reliable geographical maps for the user-perceived quality for the MNOs performance. MOC is also meant to enrich the telecommunications regulators with concrete, and up-to-date information that allows for adequate mobile market management strategies as well as appropriate decision making.*

KEYWORDS: Mobile Performance Mointoring; Crowd-Sourced Applications; Mobile Boradband Performance; Cellular Networks Monitroing

INTRODUCTION

The cellular mobile phone users and networks have both increased dramatically over the last two decades. The mobile networks are now required to cover everyone everywhere on earth. Each mobile network conveys thousands of Base transceiver Stations “BTSs” to avail coverage for their 3G and 4G broadband users. Despite of the technological advances, these networks still suffer from some of the issues related to the network performance. Such issues include the cell coverage limitations, the air interface interference, and the area specific network traffic [1]. Thus, the need for monitoring the quality of such performance has become vital for both MNOs and telecommunications regulators in order to keep such market competition fair and most beneficial for users.

Several methodologies are currently used to monitor the cellular mobile networks performance such as the electromagnetic propagation simulation to predict the wireless network performance; however the complex nature of these propagations paths lead to only approximate results from these simulations. Another widespread methodology is the drive testing and walk testing which both lead to more accurate results but therefore require very expensive specialized test equipment. [2] and [3].

The rise of crowd sourcing is spotted nowadays as an effective tool of quality measurement as well as a power driving the future in [4] and [5]. Crowd sourcing is already applied in the

telecommunications filed. Several attempts are made to achieve the monitoring of the mobile networks performance in a variety of terms based on crowd sourcing.

In [6] a patented method for estimating wireless network coverage is presented. This method includes receiving crowd sourced location data from a plurality of mobile devices located within the range of an antenna in a wireless network. The location data is mapped onto a grid of districts and down-sampled for respective districts of the grid. An approximate coverage region of the antenna is calculated based at least in part on the down-sampled location data. This method produced micro-level precise maps but lacked the macro-level representation of maps for a wide area of coverage.

In [7] a novel crowd sourced approach to the cellular network coverage analysis is demonstrated. This approach depends mainly on obtaining location based specific network measurements from the users mobile devices. Large dataset of measurements is generated using crowd-sourcing to produce a location-based maps of good accuracy. This approach is still applied only on the cell level and not on the cellular mobile network operator as a whole.

Another remarkable monitoring attempt where a new tool to analyze the performance of a cellular base station is proposed in [8]. The analysis is based on the joint processing of the received power and quality measurements both in the uplink and the downlink. The main objective of this tool is restricted to fully describe and, therefore, to detect situations involving abnormal interference levels.

MOC System Overeview

MOC is divided into two main components, namely the client component and the server component which both interact as shown in Figure 1.

Fig. 1. MOC System Overview

The MOC Client

The MOC client runs on the end-user handset to collect network information from the end user perspective. The client relies on the smart phone sensors available on the end user handset including signal strength sensors and GPS sensors to report information about the network in specific locations to the backend/server component.

The client uses the store-and-forward method to collect the required information and to store it on the end-user handset to be forwarded to the MOC server either on-spot or later according to the user configuration. This store-and-forward feature in the client allows the user to send the collected data in his/her preferred and less costly way such as the Wi-fi connection at home, or the 3G mobile data connection. The collected network information by the MOC client are as follows:

- User registration information on the system for profile access.
- MSISDN.
- Signal strength.
- Last call state of termination (normal or cut).
- Last data session state.
- Time stamp.
- GPS location.
- Cell ID.
- Cell Location Area Code (LAC).
- Phone International Mobile Station Equipment Identity (IMEI).
- Network type (GSM, EDGE, UMTS, HSDPA, etc.).
- MNO name.
- MNO code.
- Phone operating system version.
- MOC client application version.
- Average upload speed (upon user request).
- Average download speed (upon user request).

Optionally the indoor location is collected based on the mobile operating system location detection service, however this is not recommended as the service is not meant to be for the telecom accuracy.

The MOC client requires only minimum interaction with the mobile handset user however, this client allows changing some of settings including the following:

- The MOC client status switching (on/off)
- The frequency of updating the collected network information.
- The geographical distance required to be covered before this updating.
- The option of sending the information through the available Wi-fi networks only, or through the mobile data network as well.

MOC Server

MOC server is merely a group of server machines connected to the Internet where the clients send all their collected information to it to be analyzed and visualized. The server is based on the Master of Things IoT Application Enablement Platform (AEP) [9], and hence, it has very powerful capabilities as well as great flexibility to meet the needs of both of the telecommunications regulators and MNOs such as the following:

- Scaling and expansion of the system with no down-time where new server machines can be added to the system, either to scale-up, or to allow the data of each MNO in the market to be stored on a separate server machine.

- Supporting Geographical distribution where the mobile network information collected is re-routed or re-directed for storage and analysis on different servers, based on the geographical location of the end user. This traffic re-routing is done seamlessly form end user perspective.

- Enabling regulators and MNOs to create their own custom/new pages, reports, or processes.

- Providing advanced code window to allow for custom applications development using Java Script.

- Creating map-based reports for specific region. This is a very important feature for handling huge data received from large number of MOC clients.

- Blogging feature for the MNO or regulator personnel to collaborate with comments and provide feedback or get into discussions on the reports (data charts, values for sensors readings, etc.).

- Grouping the system users (MNO or regulatory authority personnel) according to their access rights.

- Creation and management of events and notifications, sending e-mails, SMS, or generation of alarms based on specific events received from the phone (i.e. location with very weak signal no coverage, etc.).

- Encryption of the data via the fast reliable encryption standard Advanced Encryption System (AES) to ensure the data integrity (i.e. information is not manipulated or changed by intermediate proxy servers).

- Readiness to be cloud hosted (either private or public cloud).

MOC Pilot Testing

The MOC system was subject to pilot testing via implementing the MOC servers on Internet while allowing the download of the MOC client software to a number of smart phones all over Egypt. The pilot testing results for the three MNOs working in Egypt (Mobinil, Vodafone, and Etisalat) as obtained from four of the working handsets running the MOC client software over the Giza area in Egypt for four months are shown in Fig 2, Fig. 3, and Fig. 4. The green color in the figures demonstrates good quality of signal, the yellow color demonstrates an acceptable quality of signal, and meanwhile the red color demonstrates a bad signal quality. The signal levels are calculated according to a metric of 30 where the good quality is from 20 to 30, the acceptable is from 10 to 20, and the bad is from 0 to 10. The quality of signal is directly related here to monitoring the quality of coverage for each of the MNOs.

Fig. 2. Mobinil Egypt Quality of Performance over Giza

Fig. 3. Vodafone Egypt Quality of Performance over Giza

Fig. 4. Etisalat Egypt Quality of Coverage over Giza

The MOC system can be customized to be implemented worldwide for any set of MNOs running in any named country. MOC is very helpful in the comparative analysis between the performances of several MNOs within any named country. Fig.5, Fig. 6, Fig. 7, and Fig. 8 shows

a comparative analysis using MOC for two MNOs in Egypt (Vodafone and Mobinil) over the same geographical areas (Banha and Tanta).

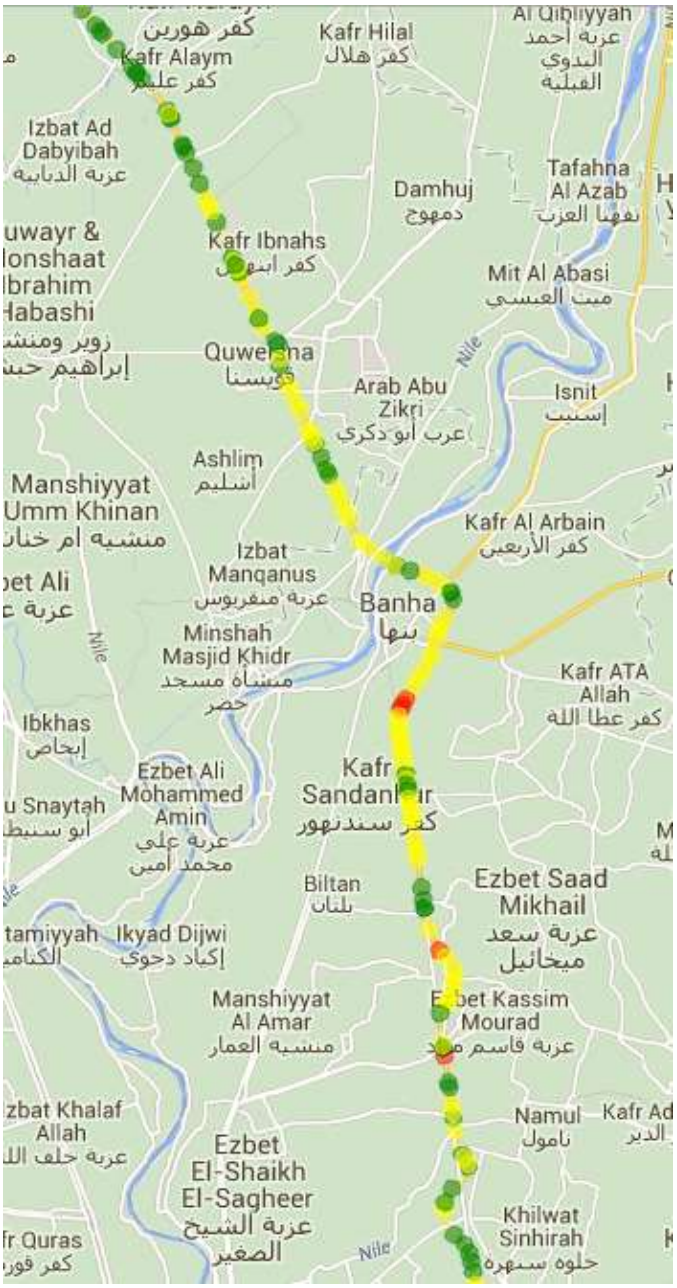

Fig. 5. Mobinil Egypt Quality of Performance over Banha

Fig. 6. Vodafone Egypt Quality of Performance over Banha

Fig. 7. Mobinil Egypt Quality of Performance over Tanta

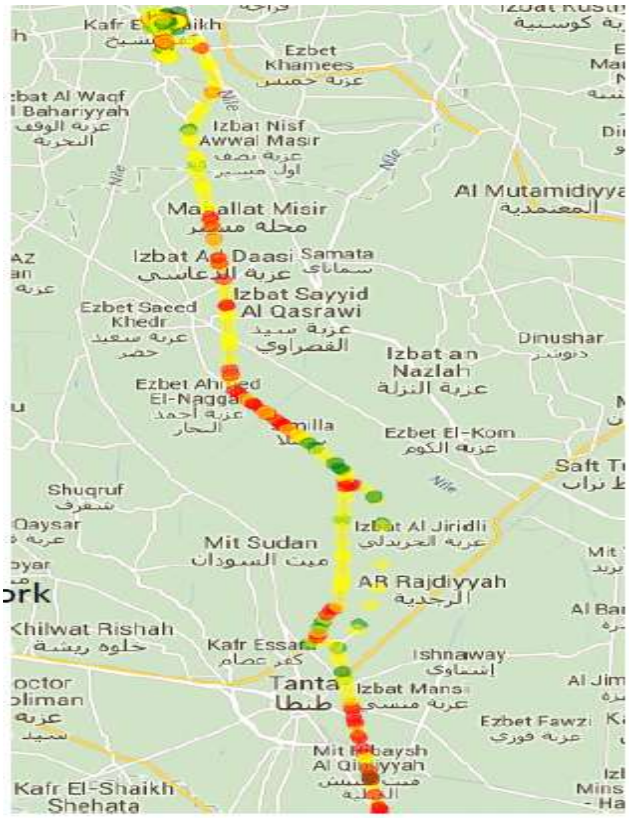

Fig. 8. Vodafone Egypt Quality of Performance over Tanta

Fig. 9 shows a pilot testing for MOC on the worldwide scale to exemplify this idea as demonstrating the quality of signal of some MNOs worldwide. The figure also shows that MOC can be used by ships in the middle of the ocean to measure the quality of the available MNOs coverage.

Fig. 9. MNOs Quality of Performance Worldwide

CONCLUSION

Monitoring the cellular network performance is an essential demand now for the regulators, the MNOs, and users. MOC is a crowd sourced system that facilitates this monitoring process vastly beyond the other existing methodologies for such monitoring. MOC has been developed as a cloud-ready application based on the client/server model. MOC has been extensively tested in terms of monitoring the quality of performance for the three MNOs working in Egypt, and in terms of performing a comparative analysis between their performance as well as worldwide pilot testing. MOC has shown significant success in the pilot testing, and can be currently offered as product for regulators, MNOs, and users.

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