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Measurement and Evaluation of Signal Levels of Cellular System Operators in Samsun City Center

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ABSTRACT: In this study, the signal levels of 2G and 3G were measured by drive test method on a specific route in Samsun city center for three cellular system operators. Smartphones with the Android system and NetMonitor application were used in measurements. Analysis results show that; 2G signal levels are higher than 3G signal levels, there is no insufficient signal strengths for 2G, and there are inadequate signal levels measured in some areas for 3G. Moreover, it is concluded that the received signal strengths change depend on measurement region (i.e. branch road, boulevard, intersection), line of sight, and output power of base station. With the transfer of measurement results to MapInfo software the colormaps of signal strengths for Samsun city center were created. By using these maps the parts that need enhancement in signal quality can be determined.

KEYWORDS: Cellular system, 2G, 3G, Drive test, Netmonitor, MapInfo.

I.INTRODUCTION

Communication has an increasing important role in human's daily life, and developing speedily with the technological improvements. Many new generation devices have been presented with the creation of new technologies. Nowadays, mobile phones have become the basic telecommunication tool, and an indispensable part of our daily lives. In mobile communication systems electromagnetic waves carry the information from the transmitter to the receiver. A cell is the area within which a base station can send and receive data. The base station is located at the center of the cell and operates within the specified frequency range [1]. A cellular mobile communication system consists of several cells, which may overlap and allow supporting the whole geographical area with the mobile communication service. When a user moves from one cell to the other, the user channel is shifted from one base station to the other easily without interrupting the call.Theoretically hexagon shape is used as the cells in mobile communication because it provides the most effective transmission; however, in practice it does not give the actual coverage area.A cell is defined by its physical size andthe size of its population and traffic patterns. In cellular systems coverage and network planning are important issues and determined depending on number of user and features of the area to be served [1-2]. With the application of this planning process the maximum number of users can send and receive adequate signal strength in a cell. With the growth in the capacity of mobile communications, the size of a cell is becoming smaller and smaller: from macrocell to microcell and to picocell. Since the maximum coverage area of a base station is 35 kilometers, the cell radius, and output power are reduced, more base stations must be installed in order to maintain quality of service [3-4].

In cellular systems the location of base station antennas are determined generally so as to ensure the best coverage area. The transmitted signal propagates through either Line of Sight (LOS) path or different paths due to the presence of buildings, mountains and other such obstructions.The effects of multipath include constructive and destructive interference, and phase shifting of the signal. The movement of receiver or the surrounding objects affects the received overall signal amplitude or phase over a small amount of time, and complicates the whole process [5].

Currently there are three different Cellular System (CS) operators (Operator A, Operator B and Operator C) in Turkey, and 2G (second generation), 3G (second generation) and 4G (fourth generation) cellular systems are used. 900 MHz is used by both Operator A and B, while 1800 MHz is used by Operator C for 2G (GSM). All three operators use 2100MHz for 3G (UMTS). According to some recent customer surveys the level of customer satisfaction is strongly

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correlated with signal strength. Thus CS operators have put a major emphasis on their "coverage area", "signal power", and "signal quality".Measuring and evaluating the received signal strengths in cellular systems are becoming more crucial than before to provide the desired service quality. For this reason, there are many recent works focus on the cellular system signal strengths measurements [6-12]. Because of these mentioned reasons, in this study the 2G and 3G signal strengths of existing three operators are measured on a specific route in Samsun, in March 2016, then scaled colormaps of recorded values are created. The use of these maps helps operators to determine future improvements as well as the areas that need enhancement in Samsun.

II.MATERIAL AND METHOD

In this study, the signal strengths of 2G, and 3G services of the three CS operators were measured, and in order to have visual information of signal strengths of Samsun city the measurement results were then transferred on a colormap. Six same brand and model smartphones with "Android" operating system and "*Netmonitor*" application, and six sim cards whose two are for each CS operator were used in measurements. According the type of connection mode measured, the network mode of the each smartphone was adjusted to "2G only" or "3G only". In order to determine the exact measurement locations GPSs' of all phones were turned on. After the completion of these processes *Netmonitor*application was started and the signal quality of each operator was measured in terms of dBm on the determined route.Drive test measurements were conducted on boulevards and streets for both 2G and 3G, while on branch roads only for 3G, at a speed of 30-50 km/h. the measurement time was determined considering busy times of corresponding measurement location.

Netmonitor application is an Android based network software, and save the information of connected base station, signal strength, and location in both CLF (list) and KML (map) format instantly. CLF format contains the information of date, time, CID (cell ID), LAC (location area code), MCC (mobile country code), latitude, longitude and dBm. KML format allows users to create colormaps by coloring the each measurement location according to its signal strength.Examples of screen shots of 2G and 3G measurements at a measurement location is shown in Fig.1*a* and*b* respectively. In figures, Operator shows the connected CS operator's MCC-MNC number and name, Type represents the connection type, LAC defines the connected cell number, CID indicates connected sector number,while RNC and PSC show radio network controller and primary scrambling code respectively.

-a-

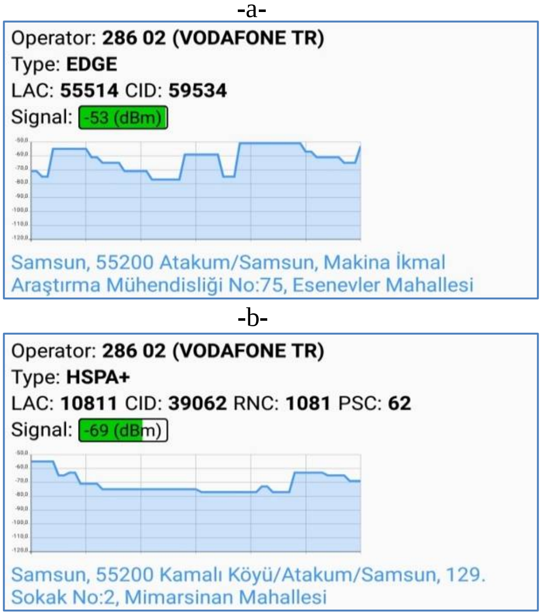

Fig.1 Examples of Netmonitor measurements for Operator B a) 2G, b) 3G

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In Turkey, Information and Communication Technologies Authority (ICTA) determines coverage area related signal strengths of CS operators with the release of communique [13-14]. In accordance with this communique minimum signal level for coverage obligation to the operators will be -104 dBm for GSM 900, -102 dBm for GSM 1800 and -104 dBm for the networks using both GSM 900 and GSM 1800. The classification can also be made according to Table I.

Table I. Signal strength equivalency table

dBm equivalent	Classification
-101 or less	very weak
-100…-91	weak
-91…-81	average
-80 or more	Good

III.MEASUREMENT RESULTS

Figure 2shows the drive test measurement results of 2G and 3G services forOperators A, B, C. In figures green color represents the highest signal strength and as the signal strength decreases it turns into red. As seen from the figure that 2G signal strengths are significantly higher than those for 3G. It is also seen from the 2G measurements that neither very weak (<-101dBm) nor weak (<-90dBm) signals concurred, and Operator C has worst signal strength. As the two of the operators use 900 MHz for 2G and according to Friis transmission equation [5]; the change in the signal strength is inversely proportional to frequency, operating at 1800 MHz for 2G may be a reason of lower signal strengths of Operator C. The measurement results of Operators A and B are examined to determine the areas with weak 3G signal strengths, and we come to conclusion that the inadequate signal levels were recorded in very few and at almost the same locations. Additionally a decrease occurs in signal strengths that recorded on branch roads, while a significant increase is observed in the levels of those recorded for streets, boulevards and intersections. On the basis of measurement results it can be confirmed that received signal strengths affected directly by measurement location, frequency, existence of line of sight path, and base stations' output power.

The measurement results are evaluated and tabulated in Table II for Operators A, B and C. It can be seen from Table II that the average 2G signal strengths are -62.28 dBm, -63.31dBm and -66.18dBm for Operator A, B and C respectively. For the case of 3G; the average signal strength is -70.73 dBm for Operator A, while -70.68 dBm and -72.58 dBm for Operator B and C respectively.

Table II. Overall assessments of measurement results

System	Operator	Signal strength (dBm)		
		Max.	Min.	Ave.
2G	A	-53	-87	-62.28
	B	-53	-87	-63.31
	C	-51	-85	-66.18
3G	A	-51	-107	-70.73
	B	-51	-107	-70.68
	C	-51	-109	-72.58

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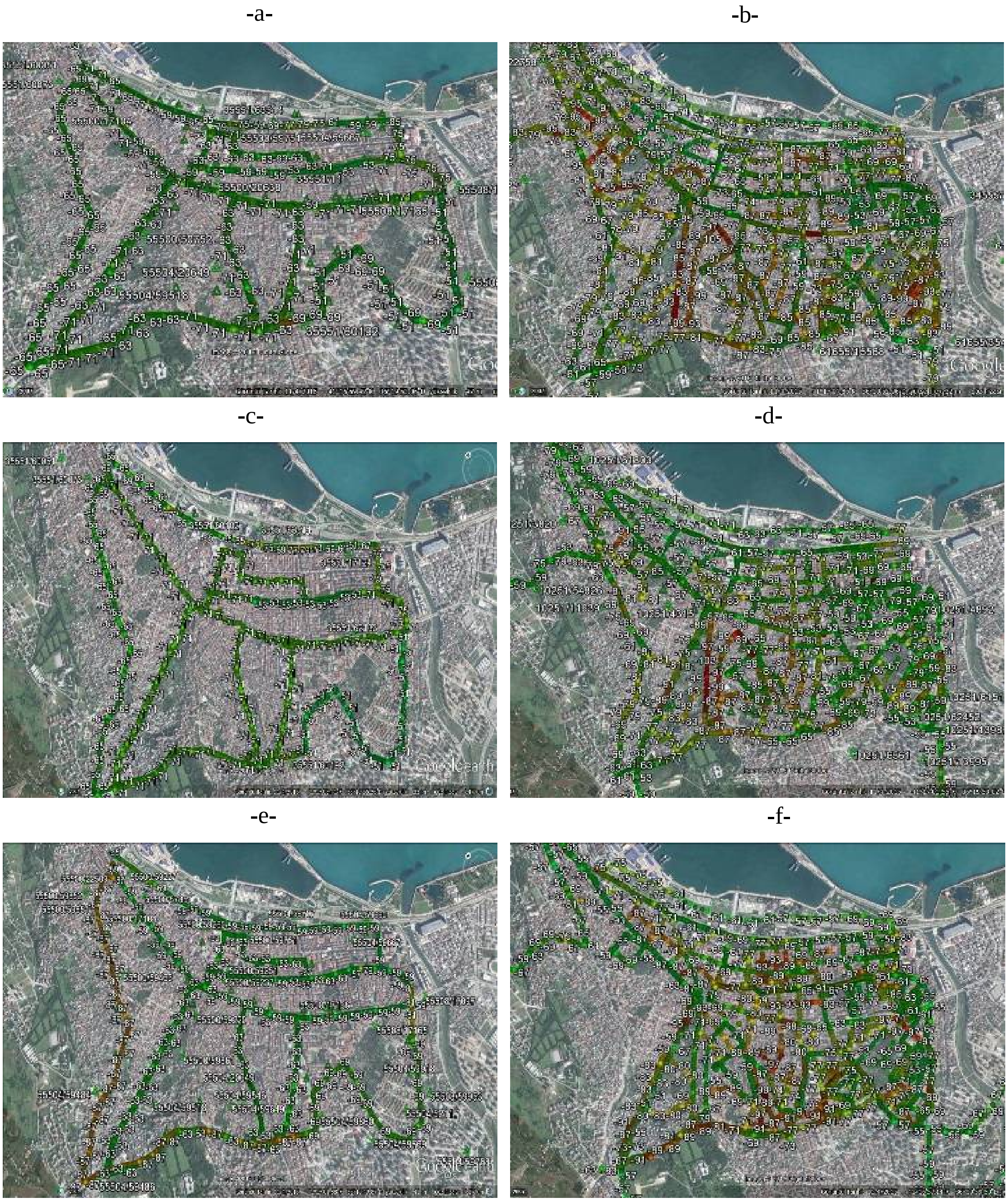

Fig. 2 Netmonitor measurements for Operator A a)2G, b) 3G, Operator B c) 2G, d) 3G, Operator C e) 2G, f) 3G

In the next stage of the study, in order to illustrate each measurement location's signal strength; Mapinfo [15] was used to create the colormaps that indicate geographic locations and corresponding signal strengths in dBm, and then displayed in the Google Maps. In order to have better visualization transparency was adjusted and satellite images were illustrated in black and white. The maps of measurement results of 2G and 3G services for three all operators are given in Fig.3.

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In figures signal strengths change between -51dBm (dark green) and -99dBm (dark red). It can be clearly seen from the figures that in Samsun city center 2G signal strengths are comparatively higher than those recorded for 3G. Additionally, as a result of using 2100 MHz frequency for operation, a decrease in 3G signal strengths occurs as expected.

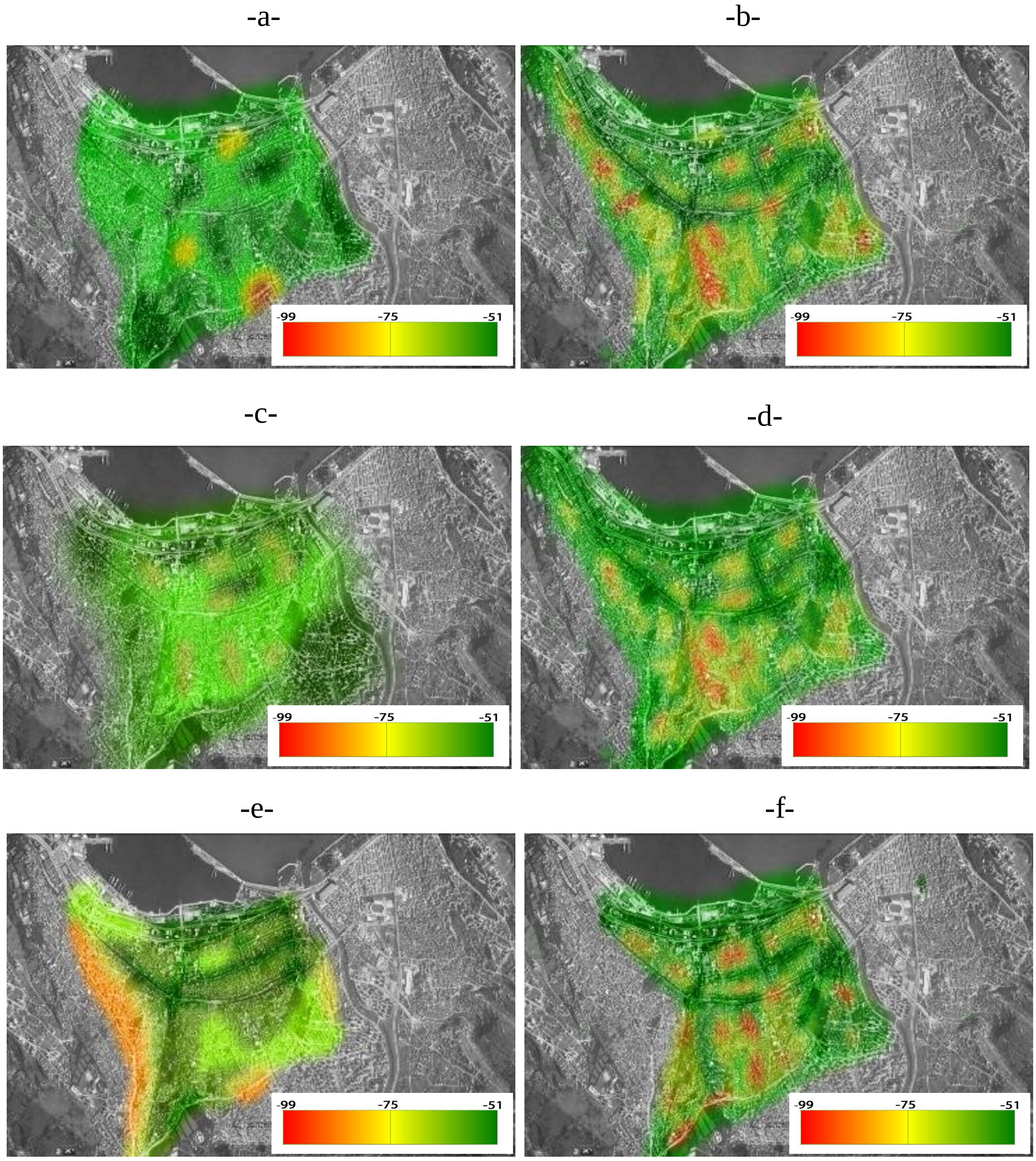

Fig. 3 Scaled colormaps for Operator A a)2G, b) 3G, Operator B c) 2G, d) 3G, Operator C e) 2G, f) 3G

IV.CONCLUSION

In this study, the signal strengths of existing three operators (named as A, B, C) in Turkey for 2G and 3G systems on a specific route in Samsun city center. It is seen from the measurement results that there is no weak signal strengths for 2G, but signal strengths of Operator C which uses 1800 MHz are slightly lower than those for the other two operators.

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Additionally, 3G signal strengths are lower compared to 2G, and the inadequate signal levels were recorded in very few and at almost the same locations for Operator A and B. It is also concluded from the measurements that a decrease occurred in signal strengths that recorded on branch roads, while a significant increase observed in the levels of those for streets, boulevards and intersections. Overall assessment of measurement results provide information to operators on the areas where 2G/3G signal strengths are lower in Samsun and where enhancements are needed.

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