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Original Research Paper

Comparison of Signal Strengths of 2G/3G/4G Services on a University Campus

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Abstract: This study aims to determine the signal strengths of three cellular system operators for 2G, 3G and 4G services on the basis of drive test measurements that were conducted twice on a specific route on Ondokuz Mayis University (OMU) Kurupelit Campus. Nine same brand and model smartphones with "Android" operating system and "Netmonitor" application were used during the synchronized measurements. Measurement results demonstrate that 2G signal strengths are significantly higher than 3G/4G, and the received signal strength can change depending on the location, frequency, line of sight, and base stations' output power. Considering all operators and both of the measurement results; the signal strengths vary from -50dBm to -103dBm for 2G, while from -51dBm to -113dBm, and from -62dBm to -130dBm for 3G and 4G respectively. The average signal strengths of both measurements for 2G, 3G and 4G vary between -79.25dBm and -63.36, -87.22dBm and -74.51dBm, -105.88dBm and -88.36dBm. The second measurement results show that the quality of signal is lower than the minimum limit (<-100dBm) determined by Information and Communication Technologies Authority (ICTA) of Turkey for 2G at some measurement locations. Furthermore, for 3G lower than the limit at 4.2% of all measurement locations for Operator C while for 4G 70.9% for Operator A. The use and comparison of these measurement results help operators to determine the parts that need enhancement, and take further actions.

Keywords: *Cellular System, Signal Strength, Drive Test Measurement, Netmonitor.*

1. Introduction

With the technological improvements, communication has gained an increasing role in human's daily life than before. These improvements have resulted in development and presentation of many new generation communication devices. Mobile communication systems especially mobile phones have become the most common tool of communication and an indispensable part of our daily lives over recent years.

A cellular mobile communication system consists of several cells, and a base station is placed center of the each cell. When a user moves from one cell to the other, the cell boundaries may be crossed from time to time, the user channel is shifted from one base station to the other easily without any interruption of the call. Theoretically each cell is hexagonal as it provides the most effective transmission. A cell is defined by its physical size and the size of its population and traffic patterns. In cellular systems coverage area classification is the first step of a cellular system design [1-2]. With the growth in the capacity of mobile communications, the size of a cell is becoming smaller and smaller: from macro cell to microcell and to picocell [3-4].

In cellular systems the location of base station antennas are determined generally so as to ensure the best coverage area. Modulated electromagnetic waves arrive at the receiver either Line of Sight (LOS) path or through different paths due to surrounding objects (buildings, mountains, trees etc.) and may experience reflection, scattering and diffraction. The received electric field strength varies as a result. This phenomenon is known as multipath fading, and the movement of the receiver or the surrounding objects make the destructive effects of multipath more complicated [5].

In Turkey, currently 2G (second generation), 3G (second generation) and 4G (fourth generation) cellular systems are used, by means of three different Cellular System (CS) operators named as Operator A, Operator B and Operator C. 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). In order to maintain customers' loyalty and gain new customers the CS operators put a major emphasis on their "coverage area", "signal power", and "signal quality" in commercials. Some recent customer surveys on CS operators show that a high level of satisfaction is strongly correlated with signal strength. CS operators must improve the provided signal quality in order to meet costumers' demands and fulfill the requirements determined by ICTA. Therefore, there are many recent works focus on the cellular system signal strengths measurements [6-12]. Thus, in this study, measuring the signal strengths of existing three operators in Turkey for 2G, 3G and 4G systems on a specific route on OMU Kurupelit Campus, transferring them on a map are aimed.

2. Material and Method

In this study, the signal strengths measurements of 2G, 3G and 4G services of three CS operators were performed once in June 2016 and once in November 2016. In measurements nine same brand and model smartphones with "Android" operating system and "Netmonitor" application, and nine sim cards whose three are for each CS operator were used. According the type of connection mode measured, the network mode of the each smartphone was adjusted to "2G only", "3G only", or "LTE only". In order to determine the exact measurement locations GPSs' of all phones were turned on. After the completion of

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these processes Netmonitor application was started and the signal quality of each operator was measured in terms of dBm on the determined route at a speed of 30km/h, during 25min. with 5sec. intervals during the busiest times of the day.

Netmonitor application which is an Android based network software, shows the information of connected base station, signal strength, and location instantly, and save these in CLF (list) as well as KML (map) format. An image for a measurement conducted with Netmonitor application is shown in Fig.1. while examples of screen shots of 2G, 3G and 4G measurements at a measurement location are illustrated in Fig.2a, b and c respectively. In Fig. 2, Operator shows the connected CS operator's MCC-MNC number and name, Type represents the connection type, LAC defines the connected cell number while CID indicates connected sector number. RNC also indicates radio network controller.

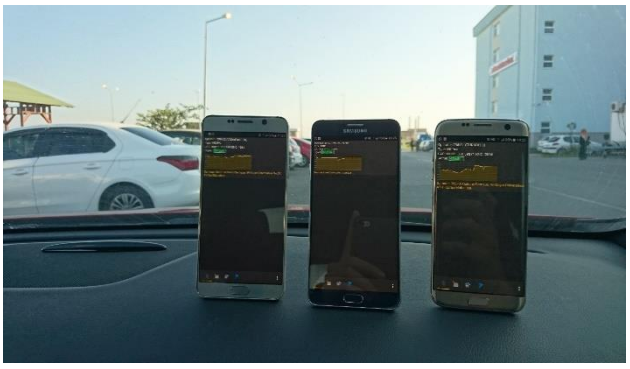

Figure 1. Netmonitor application and its operation

Figure 2. Examples of Netmonitor measurements for a) 2G, b) 3G, c) 4G

According to communique [13-14] released by Information and Communication Technologies Authority of Turkey coverage area related signal strengths of CS operators were determined. 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. Beside this, the classification can be made according to Table 1.

Table 1. Signal strength equivalency table

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

3. Results

Drive test measurement results that performed in June 2016 for 2G, 3G and 4G systems using Netmonitor are given in Fig.3.a, b, c while results of November 2016 measurements are shown in Fig. 4. a, b, c for Operators A, B, C respectively. As seen from the figures that 2G signal strengths are higher than those for 3G and 4G for both measurements. It is also seen from 2G measurements that very weak signals were recorded in a very few location in the second measurement. Furthermore, since from the first measurement Operator C has improved its signal quality. It is also concluded from the measurements that the received signal strength can change depending on the location, frequency, line of sight, and base stations' output power for all operators.

The overall assessments for the measurement results are given in Table 2 for the first measurement while tabulated in Table 3 for the second. As seen from Table 2 that the average signal strengths of 2G are -63.36 dBm for operator A, while 64.88dBm and -69.69dBm for operator B and C respectively. For the second measurement corresponding average signal strengths of 2G are -79.25dBm, -75.78dBm and 69.92dBm. For the case of 3G measurements average signal strengths are measured as -85.27dBm, -76.67dBm and -78.33dBm for the first measurement while -87.22dBm, -74.51dBm and -75.31dBm for the second. Although it has been more than six months since the establishment of 4G; very weak signals are still recorded in the second measurement at many location whose averages are -105.88dBm, -88.36dBm, and -95.03dBm for the operators A, B and C respectively.

In order to point out each measurement location's signal strength KML files are saved during drive test measurements. Then these files are used to display geographic locations and corresponding signal strengths in dBm. The obtained images are given in Fig. 5, Fig. 6, and Fig. 7. for 2G, 3G and 4G services of Operators A, B, C respectively. In figures green color represents the highest signal strength and as the signal strength decreases it turns into red. For the sake of brevity maps of the second measurement were not given. However the differences in average signal strengths between measurements are analysed and given in Table 4. It can be concluded from the table that the highest decrease occurs in the strength of 2G services of Operator A with 25% while the highest increase was observed in 3G of Operator C with 3.8%. Furthermore, there is no considerable change in signal strength of 2G services for Operator C.

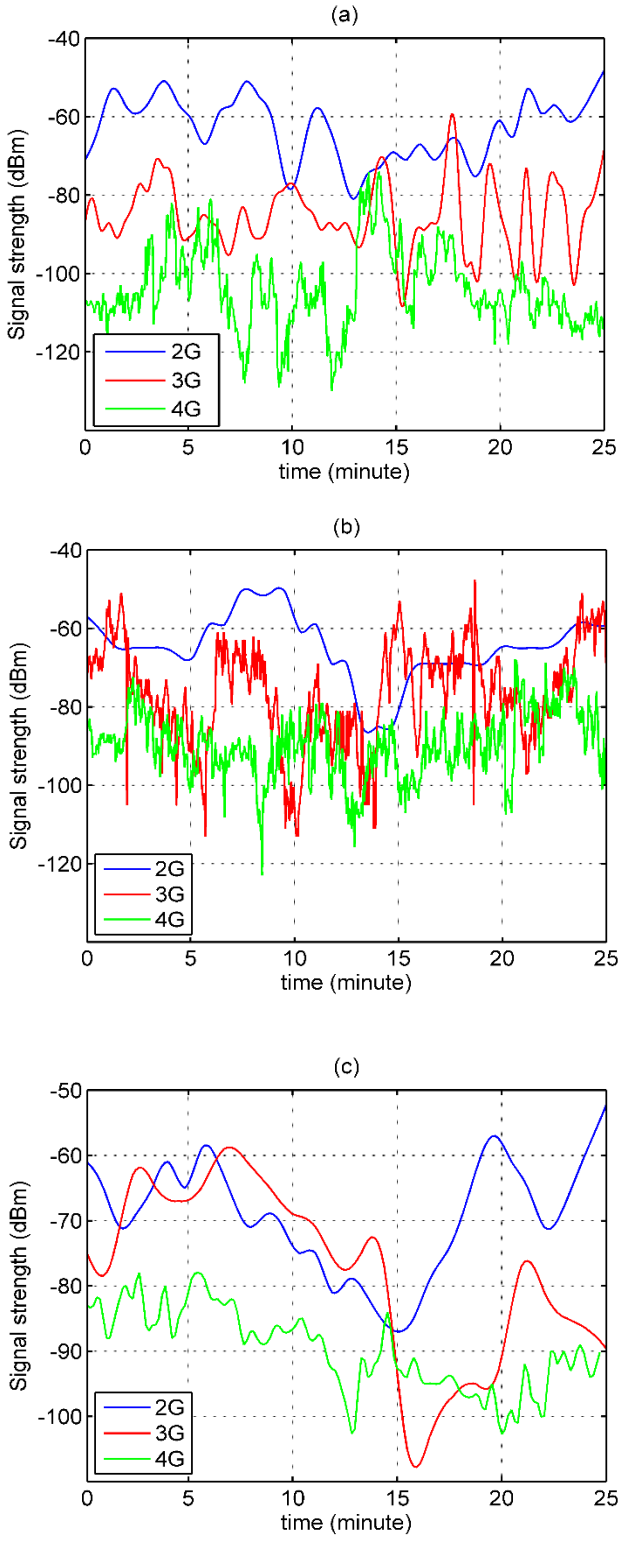

Figure 3. Signal strengths of the first measurement for Operators a) A b) B c) C

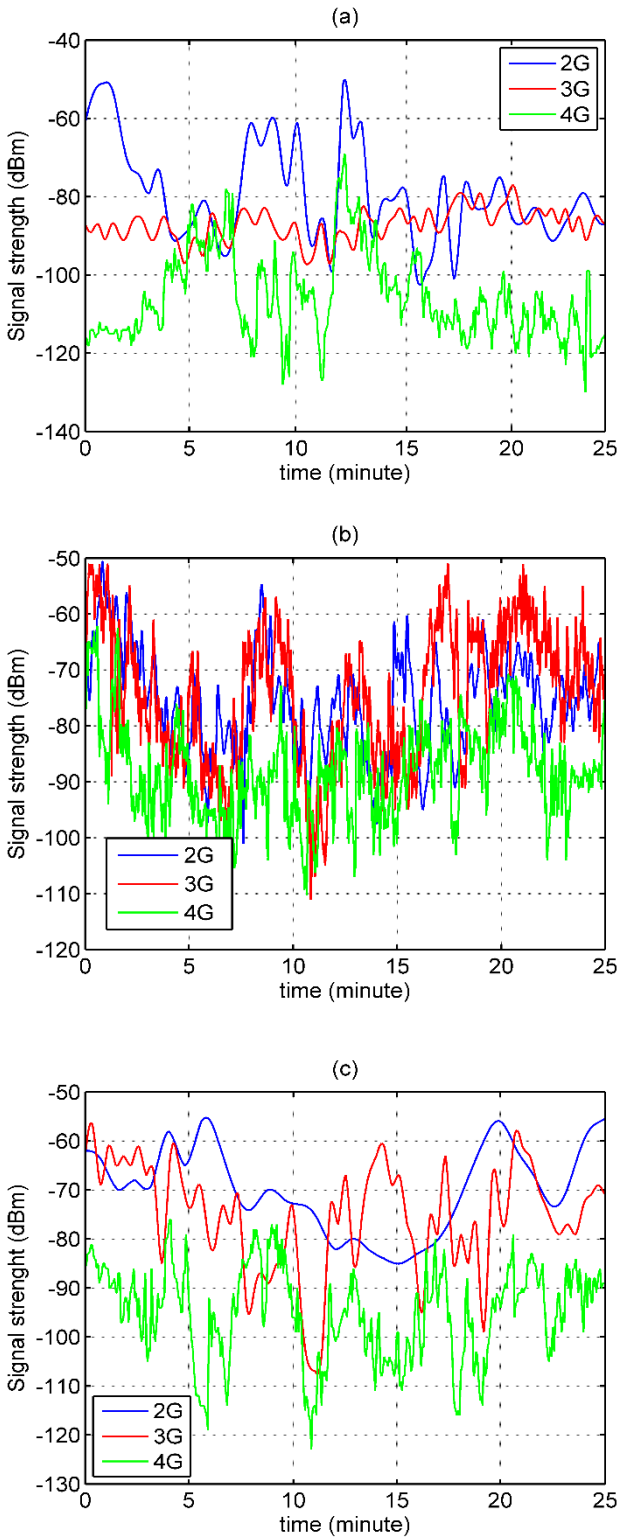

Figure 4. Signal strengths of the second measurement for Operators a) A b) B c) C.

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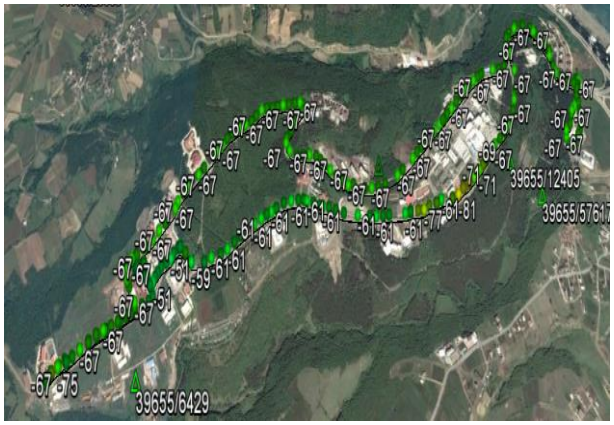

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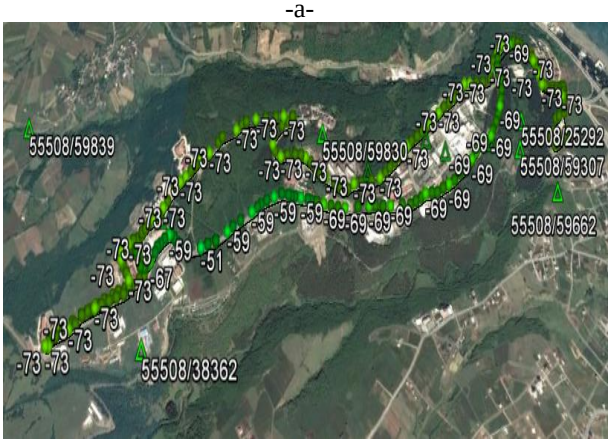

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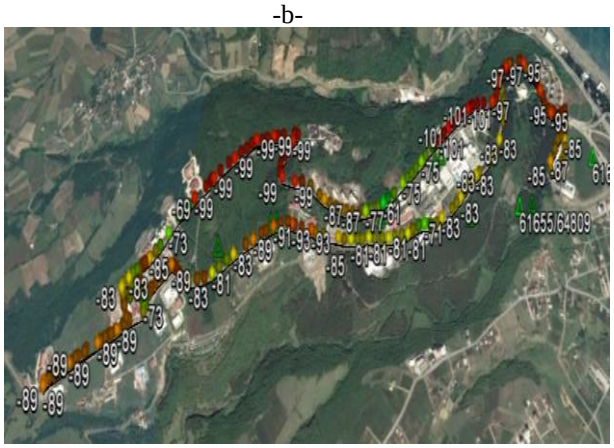

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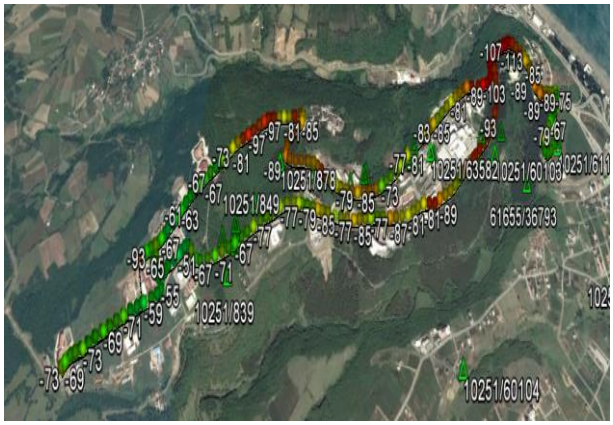

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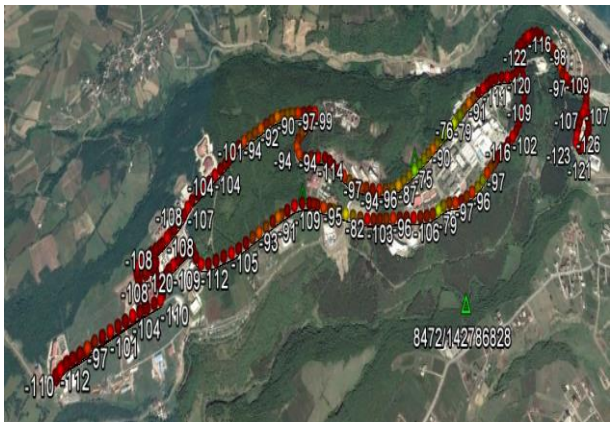

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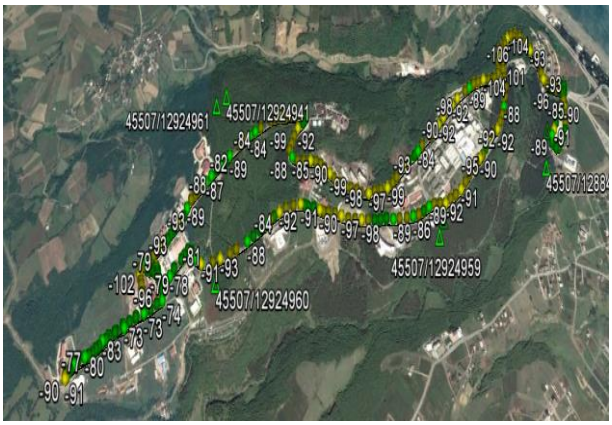
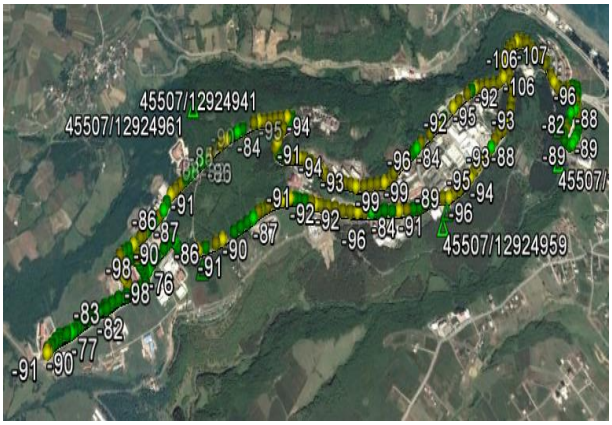


Figure 5. Netmonitor measurement results of Operator A for a) 2G, b) 3G, c) 4G

Figure 6. Netmonitor measurement results of Operator B for a) 2G, b) 3G, c) 4G

-a-



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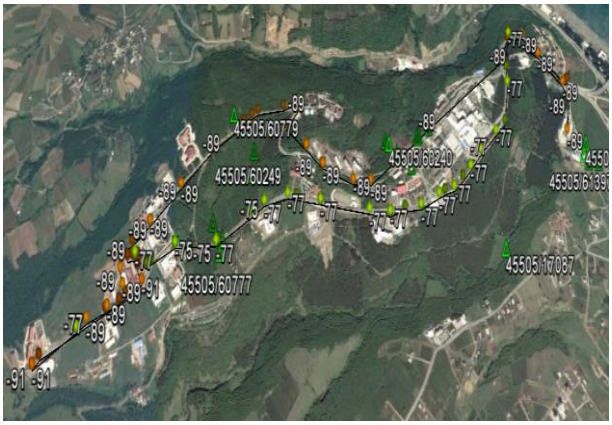

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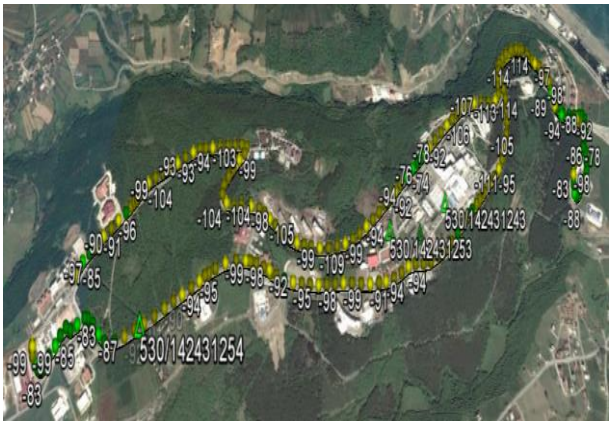

Figure 7. Netmonitor measurement results of Operator C for a) 2G, b) 3G, c) 4G

Table 2. Overall assessments of the first measurement results

System	Operator	Signal strength (dBm)		
		Max.	Min.	Ave.
2G	A	-51	-81	-63.36
	B	-51	-85	-64.88
	C	-57	-87	-69.69
3G	A	-63	-107	-85.27
	B	-51	-113	-76.67
	C	-59	-105	-78.33
4G	A	-74	-130	-104.21
	B	-67	-123	-89.55
	C	-78	-102	-89.80

Table 3. Overall assessments of the second measurement results

System	Operator	Signal strength (dBm)		
		Max.	Min.	Ave.
2G	A	-51	-81	-63.36
	B	-51	-85	-64.88
	C	-57	-87	-69.69
3G	A	-63	-107	-85.27
	B	-51	-113	-76.67
	C	-59	-105	-78.33
4G	A	-74	-130	-104.21
	B	-67	-123	-89.55
	C	-78	-102	-89.80

Table 4. Comparison of two measurement results

System	Operator	Signal strength change (%)
2G	A	25 decrease
	B	16.8 decrease
	C	no change
3G	A	2.2 decrease
	B	2.8 increase
	C	3.8 increase
4G	A	1.6 increase
	B	1.3 increase
	C	5.8 decrease

The generalized cumulative distribution functions (CDF) of three services are obtained using the second measurements' results and shown in Fig.8a, b, c for 2G, 3G and 4G respectively. It can be concluded from Fig. 8.a that for 90% of measurement locations signal strength is below -63.07dBm, -63.94dBm and -58.34dBm for Operator A, B and C respectively. In case of 3G service the corresponding strengths are -80.71dBm, -59.00dBm, -60.82dBm. 4G signal strengths are below -91.45dBm, -77.31dBm, -82.68dBm at 90% of measurement locations.

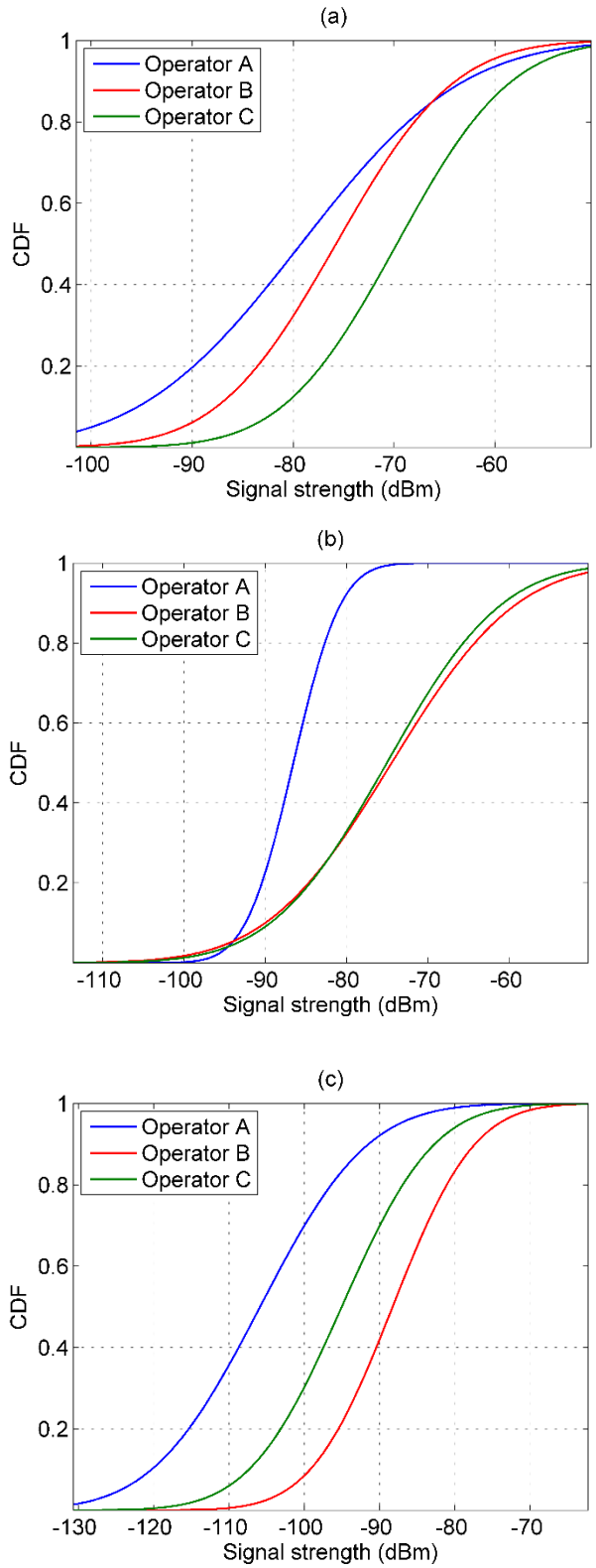

Figure 8. CDFs of the second measurement for a) 2G, b) 3G, c) 4G

4. Conclusion

In this study, in order to determine 2G, 3G and 4G signal qualities of existing three operators in Turkey, drive test measurements were conducted twice on OMU Kurupelit Campus. It is seen from the two measurement results that 2G signal strengths are significantly higher than those for 3G/4G. However, although being recorded in a very few location in the second measurement; there are some very weak signals which are lower than the minimum limit (<-100dBm) determined by ICTA. Comparison of two measurement results indicates that the significant decrease occurs in the strength of 2G signal of Operator A. Although the 4G signal strengths of Operator A and B increased the quality is still not adequate.

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