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Analysis of Mobile Communication Signals With Frequency Analysis Method

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ABSTRACT

In this study, mobile communication signals accessed by users were measured and the signal strength performances of GSM networks were evaluated. Through a developed program, communication signals of three GSM networks serving in Turkey were received from mobile phone and a data base was created. The assessments have been made on this data on base of a frequency analysis. Assessments of the 100 data obtained separately from each GSM network from 100 stable points through a way nearly 20 km a way from Gazi University Central Campus to Gölbaкē Campus were showed that; Network A has been the best signal strength performing with 83% well-signal ratio in 3 networks and a significant class difference among Network A and the other networks has been observed. Network A was followed by Network B and C with the ratios of 39% and 28% respectively. In terms of the stability of signal, Network C has been the most stable network. It is proved that although the companies providing mobile communication services announce their widespread coverage area, the signal strength levels accessed by users show significant differences among the networks.

Keywords: *Mobile communication, signal strength, frequency analysis, GSM networks.*

1. INTRODUCTION

The Information and Communication Technologies (ICT) are in a continuous development. Besides, the number of areas which are using ICT is also spreading. The digital data produced in areas using these technologies continue to grow exponentially over time. Mobile communication area is one of the areas producing the most digital data. The number of mobile communication technology users is increasing day by day [1]. GSM networks, providing mobile communications services in Turkey are, Avea, Turkcell and Vodafone. Total number of subscribers of these companies is approximately 61.77 million people in the last quarter of 2010 [2]. Companies should offer innovations, do campaigns and improve themselves to gain new subscribers as much as keeping the existing subscribers. To achieve that, they should analyze their current situation and get some clues on their signal qualities. For users, one of the most important elements of a GSM network is the signal strength and it is followed by the price eligibility. This reality can also be seen easily from the main theme of GSM networksô advertisements. In advertisements, the signal strength, the signal quality and the price eligibility themes are frequently processed [3-5]. Although companies providing the mobile communication services announce their widespread coverage area, the signal quality that users receive changes due to some regional reasons.

With the increase of the digital data day by day, maintaining the required information in this data becomes difficult. Therefore, using techniques processing and analyzing large amount of data is of great importance. For instance, frequency analysis can be used in such cases as one of the descriptive methods. Many studies have been published in many areas with this method until now. Much work has already carried out in the field of mobile communication. The research and simulation studies for the performance analysis of GSM networks can be specified as follows. The study on the signal strength performance evaluation is one of the very important subjects for users which has been made by Savaк and Topaloĵ lu [2]. Other than this study, a PhD study from Biroĵ ul. was made in 2008 for frequency planning at GSM networks with data fusion [6]. A study evaluating the measurements of

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electromagnetic density on GSM 900 Mhz frequency during different time periods of a day was made by Bilim, Develi and Kabalcē in 2011 [7].

In 1996 Ludwin and Chlebus made a comparison study for performance of simulators for cellular mobile networks [8]. In a simulation study, which was made by Han (2002), the effects of user mobility on the handoff performance of mobile communications were researched [9].

Except for a simulation, study of performance analysis of multicast algorithms for mobile satellite communication networks was made by Thomas with his colleagues (2002). The study of Takahashi and colleagues (2003) about the bounds of performance measures in large-scale mobile communication networks was realized for GSM networkõs performance analysis [10,11]. Alfa and Luiõs (2004) study about a tandem case for performance analysis of a mobile communication networks and the evaluation of product form performance study by Yoneyama and colleagues (2006) were also two samples on performance evaluation on the mobile communication [12,13]. Survivability and performance of mobile wireless communication networks in the event of base station failure study was made by Chu and Lin (2006). Received signal strength based mobile terminal positioning error analysis and optimization from Markoulidakis (2010) was another study for the optimization of mobile communication [14,15].

Assessments made by analyzing the signal received by users put this study apart from the other studies. In addition, for users of mobile communications, this comparative performance assessment study has a great importance, in terms of demonstrating the difference between GSM networks. In terms of companies, this is a model study to get important results forward to the detection of weak signal areas and the signal improvement works. Use of the mobile communication by millions also brings competition among companies. In such a competitive environment, companies should try to optimize every stage of the service offered to the users. For the users, signal strength is one of the most important issues which are offered to the users. This situation can also be understood practically from the constant emphasize on signal strength in GSM network advertisements. This bencmarking study in the field of signal strength will be an example for all networks. In addition, it will serve as an example to mobile applications that can be made after this.

In this paper, the signal strength of three GSM networks were measured on a certain route between Gazi University Central Campus and Gölbaюē Campus. This area was chosen for this study due to the reasons of having different signal coverage of GSM networks there and being the central area of city. Thus, signal strength levels that users obtained on their mobile devices were found. A database was created with the data obtained from the signal and GSM networks signal strength performance were evaluated by realizing frequency analysis on this data.

In the second section of this study, materials and methods used in the study were described. In order to obtain the signal information, a special program was developed, so that it can perform between the mobile phone and the computer via a Bluetooth or a USB port. By running this program, data was obtained and recorded to database, and the frequency analysis method in a SPSS program was applied on this raw data. In the third part the findings obtained were described. Each of network's signal measurements were evaluated by frequency analysis and the resulting ratios were interpreted. In addition, comparative rates and graphics of networks were also indicated. The last section of the paper gives the main analysis and the discussion.

2. MATERIALS AND METHODS

A program was developed for getting the signal strength information from the mobile phones. The program got the mobile communication signals from the mobile phones and saved them in a file. For the development of the program, MS Visual Studio C#.NET programming language was used. Program interface is showed in Figure 1.

Figure 1. Program interface

The program communicated with the mobile phone through a computer from an USB port or a bluetooth. Mobile phone connection to the computer is shown in Figure 2, practically.

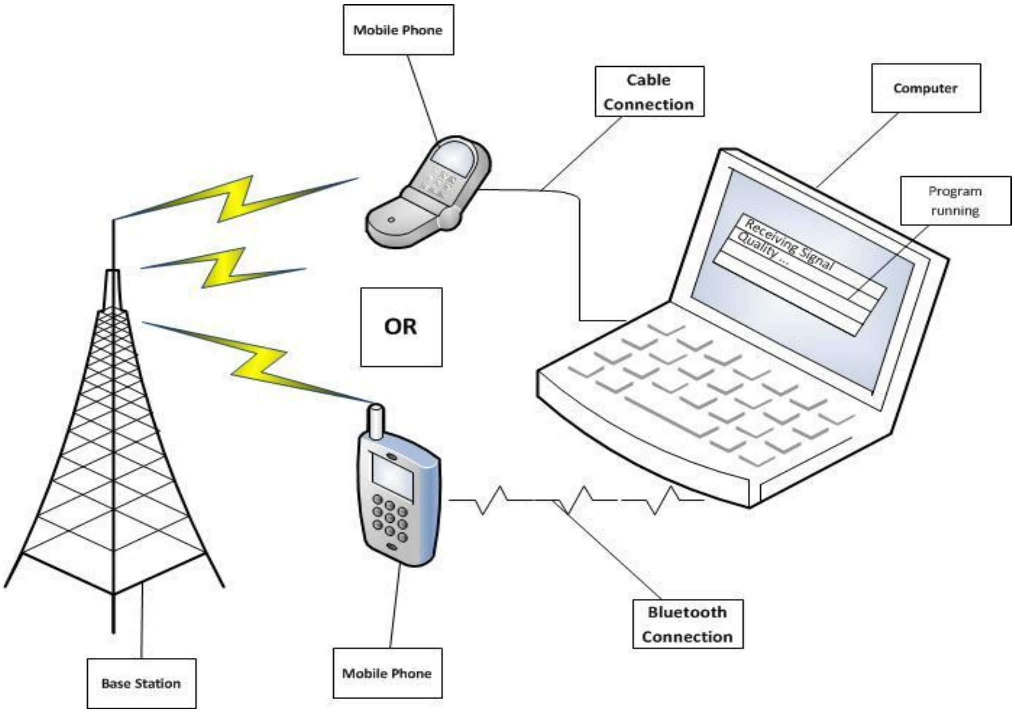

Figure 2. Computer connection with the mobile phone

The program was processed with the signal request from a stable point at every 200 meter through a 20 km route between Gazi University Central Campus and Gölbaşı Campus. The route where the signal data was obtained is shown in Figure 3.

Figure 3. The route for data acquisition

Signal measurement was realized at every 200 m along the 20 km route and 100 signal strength data was obtained for three GSM networks. Name of these networks were not specified due to the legal liability but their GSM Networks' names has been called as A, B and C through the other sections of this paper. The raw data was edited and a table was produced by using this data. In this table, both signal data and signal quality classes were classified. Answer for the signal strength request from mobile phone asked with the developed program is in the terms of "CSQ: XX,99" . Here, XX is a numeric value and it is between 0-31. Classes for these values were indicated in Table 1.

Table 1. Signal strength classification [16]

Signal strength value	dBm (decibel)	Classification (coverage)
0– 6,99	-101 or lower	Insufficient
7– 11,99	-100 ... -91	Weak
12– 16,99	-90 ... -81	Medium
17– 31,99	-80 or higher	Good
,99	-	Unknown

Frequency analysis method was applied to the data via a SPSS program.

3. FINDINGS

Frequency analysis method was applied to the signal strength data. Three networks' comparative signal - position curves are shown as in Figure 4.

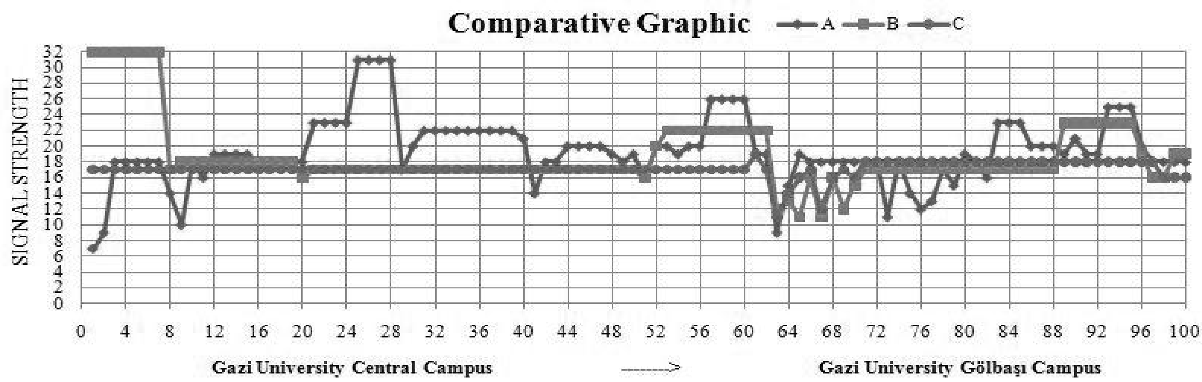

Figure 4. Signal ï position graphics of networks A, B and C

According to this, although signal strength values of network A were usually high levels, there were some fluctuations in the measured values. Likewise, there were fluctuations in network B values. There was another notable situation for B network. While values of network B were at the highest levels at the first measuring points, after the 7th measure, there were some reductions on signal strength. For network C approximately at 90% of the measurement points, stable measurements were carried out with the signal strength value of 16,99. There were some fluctuations only between 60th and 70th measurement areas. Each network's signal strength measurements were detailed as in the Table 2 frequency table.

Table 2. Frequency Tables

	Network A		Network B		Network C		
Valid	Frequency	Percent	Frequency	Percent	Frequency	Percent	Coverage
6,99	1	1%	0	0%	0	0%	Insufficient
8,99	2	2%	0	0%	0	0%	Weak
9,99	1	1%	0	0%	0	0%	Weak
10,99	1	1%	2	2%	1	1%	Weak
11,99	1	1%	2	2%	1	1%	Weak
12,99	1	1%	1	1%	0	0%	Medium
13,99	3	3%	0	0%	1	1%	Medium
14,99	2	2%	1	1%	0	0%	Medium
15,99	3	3%	6	6%	6	6%	Medium
16,99	2	2%	49	49%	63	63%	Medium
17,99	27	27%	11	11%	27	27%	Good
18,99	14	14%	3	3%	1	1%	Good
19,99	13	13%	1	1%	0	0%	Good
20,99	2	2%	0	0%	0	0%	Good
21,99	9	9%	10	10%	0	0%	Good
22,99	7	7%	7	7%	0	0%	Good
24,99	3	3%	0	0%	0	0%	Good
25,99	4	4%	0	0%	0	0%	Good
30,99	4	4%	0	0%	0	0%	Good
31,99	0	0%	7	7%	0	0%	Good

As Shown in Table 2, 19, 12 and 7 different signal strength values were measured for network A, B and network C respectively. Thus, network C has the least difference between signal strength and is the most stable network in signal strength measurements. However, more than 70% of measured signal values were in medium signal class or lower levels. Therefore apart from its stable signal network C was in the medium coverage level and this is negative for performance evaluation. Similarly, more than 60% of network B signal values were in medium coverage or lower level. Network B's performance is better than network C because better signal strength were found. Network A has been the best-performing network among three networks because of its high percentage of good signal measurement and significant difference of signal quality class from other networks. Too much fluctuation in signal measurements of network A made a negative impact on this network.

Frequency tables were produced according to the classified ranges as Table 1, for better evaluation of measured signals (Table 3). Also these measured signals' ranges are showen in Figure 5.

Table 3. Classification of frequency tables

Valid	Network A		Network B		Network C	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Insufficient signal	1	1%	0	0%	0	0%
Weak signal	5	5%	4	4%	2	2%
Medium signal	11	11%	57	57%	70	70%
Good signal	83	83%	39	39%	28	28%

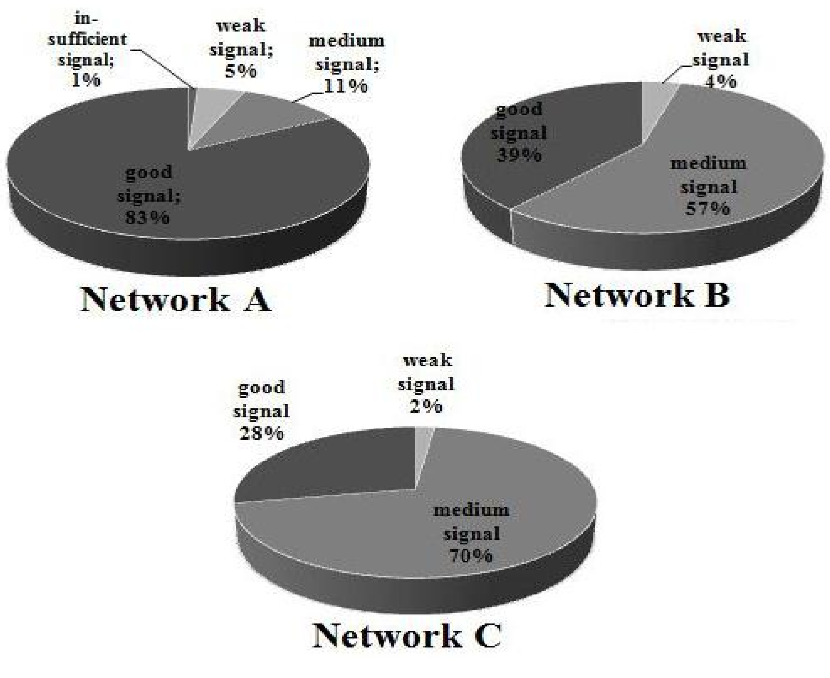

Fig. 5. Signal Classification of networks A, B and C

Network A has been the best-performing network of three networks with 83% good signal level ratio. This is followed by network B with 39% and network C with 28%. After the measurement, an interesting result also found for network A. Although network A has the highest ratio of good-signal class, insufficient and weak-signal ratio more than other networks is also obtained in its measurements. However, these measurements' ratio difference were so low that, this has not made a negative effect on network A performance. Nevertheless, the improvements for the areas where weak and insufficient measurements have been made, is another issue to consider for network A operators. Descriptive statistics at measurement points for GSM Networks, is such as in Table 4.

Table 4. Descriptive Statistics (N: Number)

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Network A	100	6,99	30,99	19,4	4,28786
Network B	100	10,99	31,99	18,82	4,40627
Network C	100	10,99	18,99	17,08	1,03568

It is as illustrated by the standart deviation and the differences with lowest and highest values that there are too much signal fluctuations at network A. This situation is not positively viewed in mobile communications. Because of this, providing a signal level stability is an issue for network A that is required a further effort. Similarly, standart deviation and difference between values for network B is too much and like network A, signal-fluctuation preventative improvement works must be done for network B. Being less standart deviation and difference between values of network C has meant the less signal-fluctuation for network C. However, network C's signal measurement values were mainly in medium signal class and therefore signal strengthening works are required. Descriptive statistics histograms for GSM Networks are showed in Figure 6a, Figure 6b and Figure 6c.

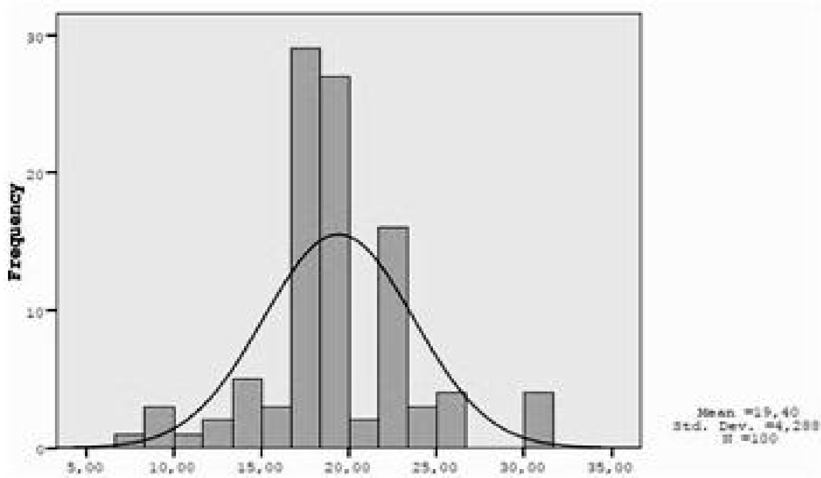

Fig. 6a. Frequency histogram of network A.

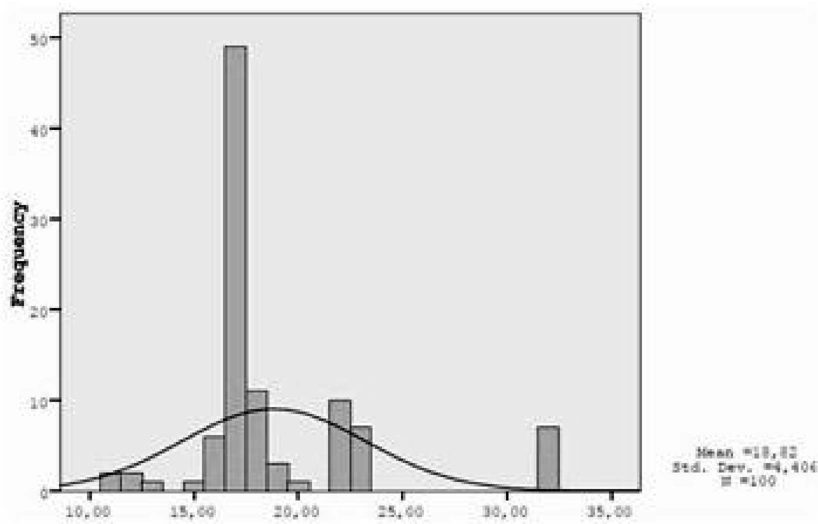

Fig. 6b. Frequency histogram of network B.

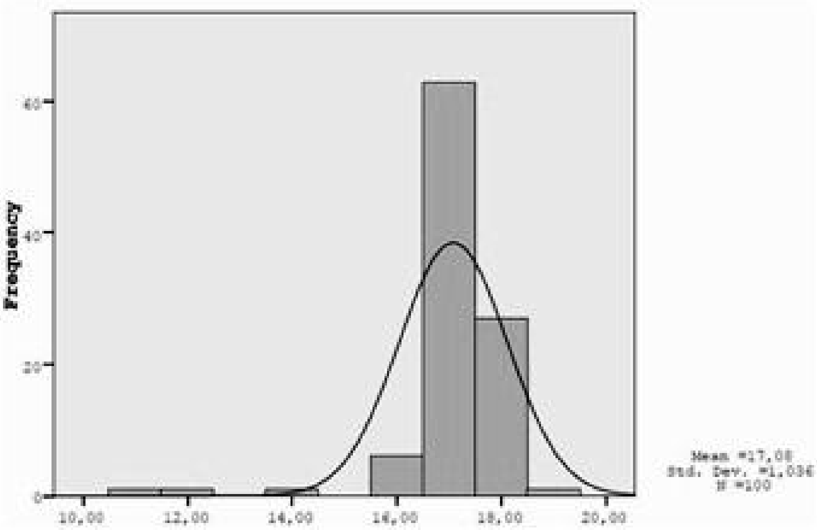

Fig. 6c. Frequency histogram of network C.

In the light of all this information, networks A, B and C were evaluated for the signal strength. The determined route is a prototype region and, similar studies can be performed in different regions.

4. RESULTS AND DISCUSSION

In this study, mobile communication signals were taken from a stable point at every 200 meter through 20 km route between Gazi University Central Campus and Gölbaşı Campus and a database was created. A program was developed for the measurement of signal strength. The program acquires the information from a mobile phone for 3 GSM networks serving in Turkey, mobile communication signals were detected in the same vehicle and at the same points. Assessments were made with the method of frequency analysis on this recorded data.

As a result of the analysis, different results were found for network A, B and C. Network A caught the best-signal ratio performance and the lowest rate of good signal was measured at the network C. However, the maximal fluctuation was detected at network A among three networks. Other important point here is that whether the signal fluctuation affects the performance of signal strenght or not.

Signal strength of network B was at medium signal level. It means that signal strenght performance of network B was in the mid-level of these three networks. According to the ratios, network B's signal level was much better than network C, thereby performance of network B was recorded as medium. Although signal stability of network C was one of its positive aspects, it didn't change its being the lowest performing network among these three networks. In addition, network C did not fall into the insufficient signal class and showed very little weak signal ratio as 2%. So, those have been a positive factor for performance of network C.

The results obtained in this study proves that the mobile communication signals can be assessed by analyzing a variety of programs. Studies similar to that, can be done more comprehensive and large-scale by the companies and can be used in the improvement processes. In addition to the rise of using mobile communication, companies should also make some efforts to increase their market share. This study has revealed some results for signal strength profiles of different networks which is one of the most important criteria for users. Future mobile applications based on this study will be a guide for the improvement activities of GSM networks.

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