INVESTIGATION AND MAPPING THE RELATIONSHIP BETWEEN 4G SIGNAL STRENGTH AND TOPOGRAPHY FOR DIFFERENT OPERATORS

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ABSTRACT: Currently, mobile technologies are one of the fastest improving technologies in the world. In mobile devices category, the most technological and preferred devices by costumers and providers are undoubted smartphones which are always changed and developed. Some of the main developments in this sector are faster downloading or uploading data, longer battery life, high quality of resolution and more qualified photograph or video. Because of the fact that every new technology is being integrated, other areas which give service in terms of smart phones have to follow these technological developments and make researches on the related topics. The signal strength levels on smartphones reach download / upload speeds within the processor and modem features used on smartphones. Nowadays, a big majority of smart phones have a far higher speed of download and upload data than the operators that provide infrastructure services. Another important aspect is the signal strength level depends on the base stations established by the mobile phone operators. Within the study, three different routes which cover different districts of Istanbul have been selected as the study area. In these routes which have different topographical features, the relationship between signal strength and topography was examined and mapped. Additionally, signal power rate which directly affect the speed of upload or download data and its performance was investigated in the study. Efficiency and capacity for the development of base stations were also studied and mapped in the study. Contrary to expectation, study results have shown that there is no strong relationship between signal strength and the topography.

1. INTRODUCTION

The high-speed dataflow offered by the technology varies depending on the operator and location of the users. Parallel to the advances in technology, mobile phones had a great changes and technological features. One of these technological developments is base stations. 4G supporting smartphones had been promoted to customers long before 4G technology was

introduced for the first time in April, 2016 in Turkey. Afterwards, it was introduced to customers when the operators were done realizing relevant investments to technological changes in their infrastructures (Minelli et al. 2014; Vora, 2015; Amine and Khireddine, 2017). These investments, due to being new, technological and high costed investments, were grown rapidly to the other cities of Turkey, starting with the cities which have got the highest population. Although the 4G services have coverage in a large part of the metropolitan areas, there is still no coverage in small cities and in rural areas of major cities (Korhonen, 2003; Mishra, 2007; Nuaymi, 2007). For this reason, users are often not able to use 4G services in these areas or have speed and service at 3G levels.

The aim of this study, taking into users' signal strength and increased high speed expectation, in three different locations in Istanbul with three different operators that operate in Turkey measurement of 4G signal strength levels, mapping of signal strength levels based on operator and location separately and identifying locations that very low signal levels with their heights is targeted. Additional aim of the study is to assist in the improvement of the signal strength by identifying locations where users experienced problems.

2. TOPOGRAPHY ANALYSIS FOR THREE SELECTED DISTRICT

With the very reach historical background, Istanbul is not only the largest city of Turkey it is the largest one in the Europe which lie on two continents of Europe and Asia. The city of Istanbul consist of many different landscapes which includes valleys, plateaus, streams, mountains and hills. While the minimum altitude of the city is 0 meters, the highest value is reached to the 530 meters. Comparing to the Asian side of the city, the European side contains more flat areas.

Three routes have selected in the study area. The first one in the Sariyer District, second one in the Istanbul Technical University Campus in the Sariyer District and the third one in the Sisli District. The first route is quite long and cover some part of the Sariyer and Kagithane Districts. The last route is in the district of Sisli, which is relatively small but very dense commercial and residential building. Due to geological structure of the area these routes cover valleys and grabens which formed in the region during the hundreds of year in past. This route has changes between 70 and 200 meters. The detailed digital elevation model of Şişli district is shown in Figure 1. (http://en-hk.topographic-map.com/places/Istanbul-4020310).

3. METHODOLOGY USED

Due to dense population and large 4G infrastructure opportunities Istanbul has been chosen as the study area. The fact that Maslak and Şişli regions have a dense population and a location where many different business sectors are active especially in the commercial area has been

effective in the selection of this region. The data collected at the designated locations were collected with a car with the help of the application named as Network Cell Info. During data collection used reference devices are specified taking into devices specs and in Turkey mobile infrastructure and frequency bands. In table 1, route definitions have been given.

Figure 1. Digital Elevation Model of Şişli District

Table 1. Route Definitions

Routes	Route Name	Abbreviation	Distance (km)
Route 1	Maslak	r1	18.7
Route 2	ITU Campus	r2	3.9
Route 3	Şişli	r3	7.2

Three telecom operators that be activated in Turkey were used for the research study and these are as given in Table 2.

Table 2. Telecom Operators Definitions

Description	Operator	Abbreviation
Operator1	Turkcell	o1
Operator2	Vodafone	o2
Operator3	Turk Telekom	o3

4. COLLECTED DATA AND ANALYSIS

Detail information about route distance, district quantities decided by operators, base station and sector quantities are given in the Table 3. The biggest base station quantity belongs to Vodafone operator in Route 1, and Turkcell in Route 2, and again Turkcell in Route 3. Also, Table 3 shows that Route 1 has the biggest collected data quantity 567 pieces with Turkcell operator, 462 pieces with Vodafone operator and 668 pieces with Turk Telekom operator

which is biggest collected data quantity. Analysis results of collected have been given in Table 4.

Table 3. Collected Data

Route/Operator	Route Distance (km)	Operator District Qty	Base Station Qty	Sector Qty	Qty of Collected Data
r1.o1	18.7	3	46	55	567
r1.o2	18.7	5	75	82	462
r1.o3	18.7	3	54	55	668
r2.o1	3.9	1	24	24	77
r2.o2	3.9	1	17	17	81
r2.o3	3.9	1	6	7	76
r3.o1	7.2	3	36	44	305
r3.o2	7.2	5	30	32	312
r3.o3	7.2	3	24	27	228

Operator-based signal strength map and signal-height relationship for Route 1, Route 2 and Route 3 are given in Figure 2, Figure 3 and Figure 4 respectively.

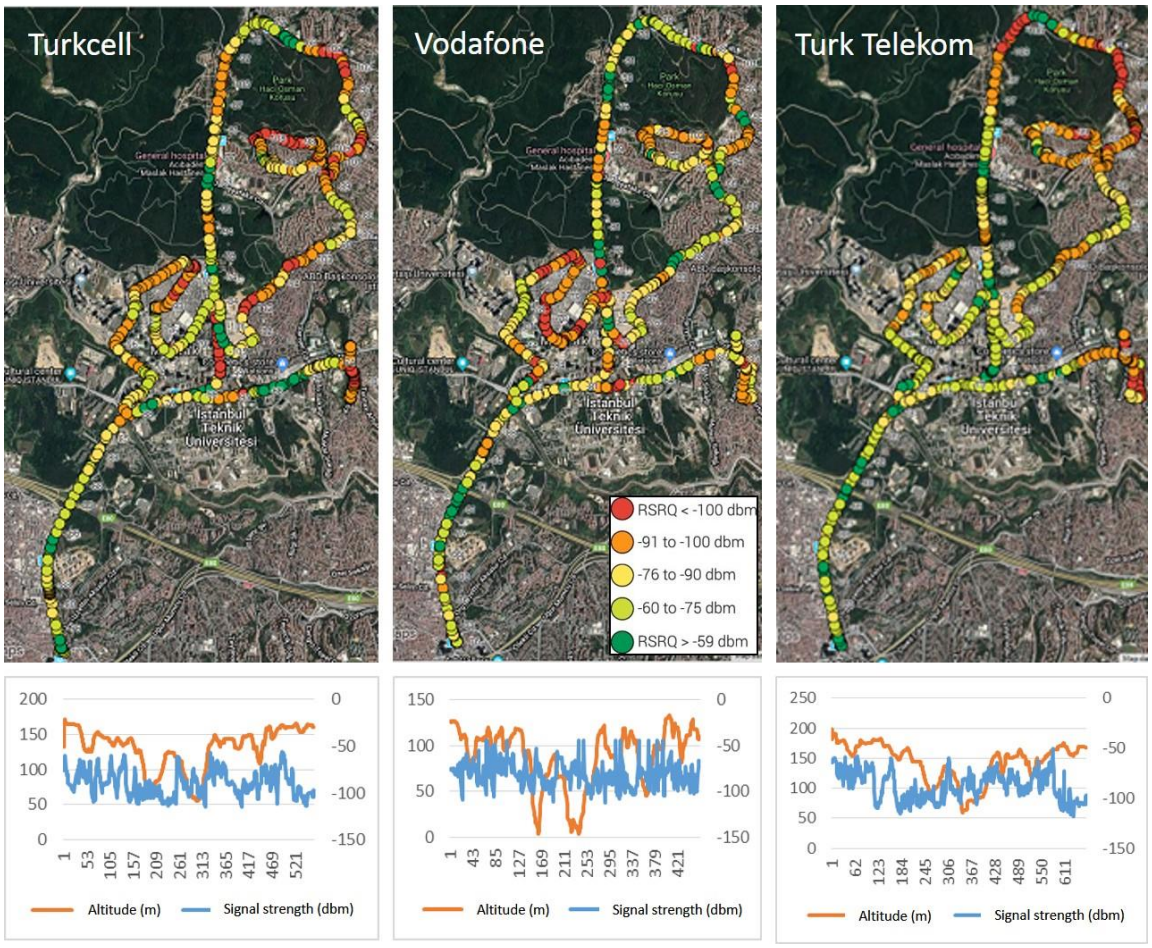

Figure 2. Signal strength map and altitude relationship of three different operators on the first route.

Table 4. Analysis of Collected Data

Route/Operator	Lowest Signal (dBm)	Highest Signal (dBm)	Average Signal (dBm)	Lowest Altitude (m)	Highest Altitude (m)	Average Altitude (m)
r1.o1	-115	-56	-89.526	55.800	171.400	130.829
r1.o2	-112	-44	-81.494	3.9	133.6	87.987
r1.o3	-118	-50	-87.684	58.5	198.6	144.342
r2.o1	-97	-52	-69.961	116.1	158.5	140.949
r2.o2	-110	-44	-80.173	55.2	126.3	91.447
r2.o3	-111	-65	-90.342	123.7	163.8	144.629
r3.o1	-113	-44	-83.931	5.5	165.5	108.171
r3.o2	-111	-56	-84.362	113.3	183.8	156.491
r3.o3	-113	-54	-81.987	96.9	182.3	148.949

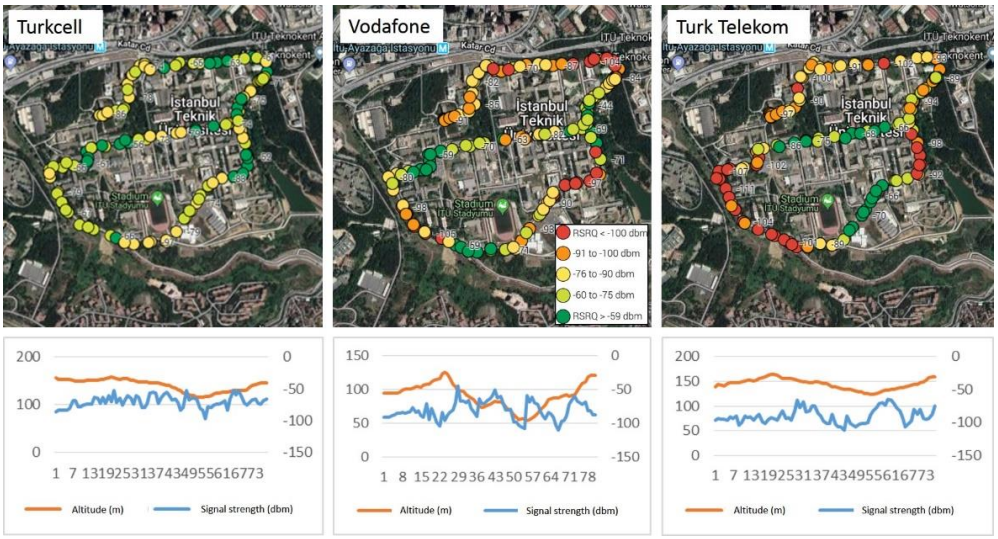

Figure 3. Signal strength map and altitude relationship of three different operators on the second route.

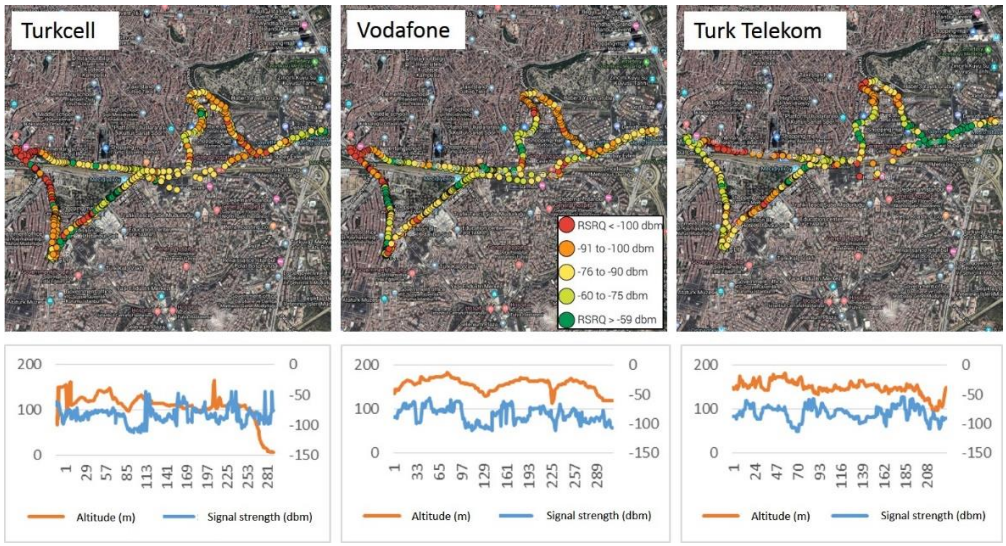

Figure 4. Signal strength map and altitude relationship of three different operators on the third route.

When the figures of Route 1 is examined, it is seen that the signal strength of the data collected by Turkcell operator is approximately 78% in the middle and above signal strength category and the remaining 22% is in the weak and lower signal strength category. For all three operators, improvements in signal strength were observed at some higher points, while at some higher points was observed that there was a decrease in signal as the height increased. For example, in Turk Telekom signal strength-height relationship graph, between samples 326 and 340 observed that the signal strength decreased while the height decreased, is observed that the signal strength increased as the height increased between the samples of 380 and 401.

When Route 2 and Route 3 are examined, for all three operators, at some higher points improvement in signal strength were observed, while at some higher points were observed that there was some decrease in signal where the altitudes are increased.

According to the signal strength data collected at all locations, the operator with the best signal strength of Route 1 was Vodafone with -81.251 dBm. The second best operator with the signal strength is Turk Telekom with -87.933 dBm. Thirdly, it was seen that it was Turkcell operator with -89.823 dBm. The operator with the best signal strength of Route 2 was Turkcell with -70.205 dBm. The second best operator with the signal strength was Vodafone with -79.216 dBm. Turk Telekom with -90,407 dBm ranked third in signal strength comparison.

The operator with the best signal strength of Route 3 was Turk Telekom with -82.089 dBm. The second best operator with the signal strength was Vodafone with -83.297 dBm. Thirdly, it was seen that it was Turkcell operator with -83.432 dBm.

According to data in Table 3, the Vodafone operator with 75 base stations is the operator with the highest number of base stations on Route 1. For Route 2, the Turkcell operator with 24 base stations is the operator with the highest number of base stations. Finally, the Vodafone operator with 43 base stations is the operator with the highest number of base stations on Route 3.

When the data in Table 4 is examined, it is seen that the total number of base stations of Turkcell operator is 24% less than the total number of base stations of Vodafone operator, but it has the best average signal level. The second best signal strength is Vodafone operator and the third best signal level is Turk Telekom operator.

5. RESULTS AND CONCLUSIONS

In this study, the locations and heights where signal strength is critical for 4G services by gathering information such as signal strength, height, position, base station identity by using 3 different telecom operators and 3 different locations in Istanbul were examined and

determined. As a result of the tests performed with telecom operators in the 18.7 km area in Maslak location, the average signal strength was found to be in the well-accepted range. Tests carried out at different points with different operators have shown that the signal strength is almost too bad to provide 4G services and even low-quality sound transmission.

As a result of the tests carried out in the 39 km area of the ITU campus location, the average signal strength observed sufficiently for some operators. It is observed that the signal strength is low in the places where are far from the settlement which are generally the lower part of the campus. This is due to the fact that the operators are further away from the base stations.

In the area of 7.2 km of the Şişli District, the population is taken into consideration. It is seen that the signal strength levels are related to the population density. As the population density increased, it was found that there was a decrease in the signal strength of the users due to the increase in base station density.

When all collected data were examined, it was observed there is no clear relationship between altitude and signal strength. It has been found that the signal strength is high at some high points, while the signal strength is low at some high points. Depending on the position and height of the base stations, the signal strength increases or decreases with respect to the height. It was observed that the signal strength was significantly lower in some locations. It has been found that in these levels, the users are unable to perform even the simplest service of voice communication or perform in very low quality.

The data collected in this study aimed to experience the problems of low signal strength experienced by the users and help to find the root cause of these problems. The signal strength maps generated by the collected data were presented along with locations that have the signal strength problems and altitude information. Moreover, this data is intended to assist with possible improvements in locations with low signal strength.

6. REFERENCES

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