BIG DATA ANALYTICS IN THE CONTEXT OF MOBILE NETWORK PERFORMANCE OPTIMIZATION

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Abstract: Crowdsourcing is a modern and growing technique of acquiring large amount of information. This project utilizes the data on mobile connectivity gathered by RTR NetzTest application to evaluate the performance indicators of the network. The software tool capable of assessing the network based on location, operator and other parameters will be created and utilized for benchmarking of the Austrian network operators. The software tool will be able to monitor the individual telecommunication nodes to estimate their performance in time.

Keywords: Big Data, Crowdsourcing, LTE, Mobile Network, Open Data

1 INTRODUCTION

This project focuses on the analysis of Austrian LTE networks based on the crowdsourced end-user measurements. The primary source of the data is the application RTR-NetzTest [1] provided by RTR (Austrian Regulatory Authority for Broadcasting and Telecommunications). The results of all the measurements are available as open data [2]. For the analysis, the MATLAB programme has been created to assess three the most viable parameters for each user: downlink throughput, uplink throughput and latency (TCP round trip time). The programme statistically compares the three largest operators in Austria and ranks them based on these parameters. The spatial analysis divides the considered region into bins and assesses the network parameters bin-wise, as well as using the clustering algorithm.

2 MEASUEREMNT BREAKDOWN

There are plenty of ways to assess the performance of the network. The gathering of data is usually done by the direct measurement of various parameters of the network and later processing of the acquired data. The measurement may take place either on the side of the provider, in the telecommunication node called eNodeB for LTE Radio Access Networks (4G), or on the side of the user. The performance on side of the user is evaluated either by specialized measurement equipment able to assess the information about the network or by a generic user equipment using specialized application. The process of gathering information from a large number of users using a common tool is called crowdsourcing [3]. The crowd of anonymous end-users contributes measurements conducted by diverse device models at different locations and at different times. The advantage of crowdsourcing is that we have access to hundreds of thousands of measurements without having to spend any resources. The drawback is that the results may differ for two users at the same network state due to device limitation, tariff limitation etc.

The power of crowdsourcing lies in the number of results which the crowdsourcing platform is able to gather. The negative aspects of the user diversity can be compensated by the sufficient number of representative samples and by proper processing of the gathered data. This project utilizes the open data provided by RTR gathered using NetzTest mobile application. We consider all LTE tests conducted in Austria in the year 2018 - the dataset consists of over 380000 samples. We exclude all incomplete tests, lacking crucial information such as operator information or signal strength measurement as well as measurements done while roaming.

The data consists of both temporal and spatial information. As the consequence of the data being gathered using crowdsourcing, the distribution of measurements in time and space is not uniform, see Figure 1 a), where the measurement heat map of Austria is depicted. It is apparent that the majority of measurements took place in highly populated areas and along main transport routes (highways, train tracks). As Figure 1 b) reveals, even the centre of Vienna is not consistently covered with measurements, having more data on frequently used routes. The temporal inconsistency is the result of varying user activity throughout the day, as well as depending on the weekday.

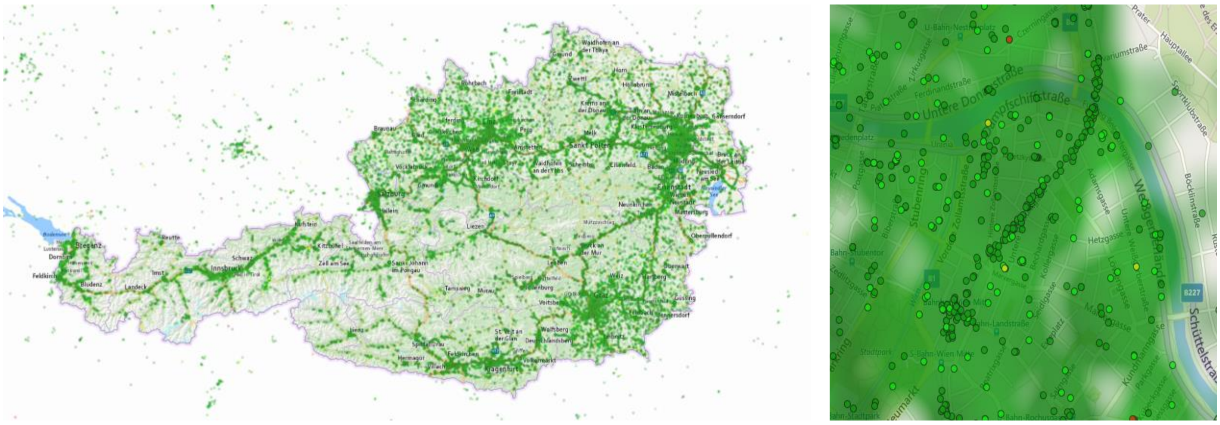

Figure 1: a) Map of Austria with the heatmap of the measurements over 1 year, LTE networks, 20 percentile, all operators; b) Heat map of the measurements in the centre of Vienna over 3 months, LTE, 20 percentile, all operators [2]

3 ANALYSIS

The three basic quantities will be considered in the analysis: downlink throughput, uplink throughput and latency. These were chosen as the most representing parameters for the user to assess the quality of cellular network connection.

3.1 RESULTS PER OPERATOR

The analysis focuses on the comparison of three largest LTE mobile network operators in Austria, namely A1 Telekom Austria (A1), T-Mobile Austria (T-Mobile) and Hutchison Drei Austria (H3). Table 2 presents the number of measurements per operator in the year 2018, as well as mean and median downlink throughput and latency of each operator. The data show that by comparing these parameters, T-Mobile leads in 3 out of four considered categories and H3 scores lowest in every aspect.

Table 1: Test results per operator

Operator	**Number of measurements [-]**	**Downlink mean [Mbps]**	**Downlink median [Mbps]**	**Latency mean [ms]**	**Latency median [ms]**
A1	57721	44.78	30.48	29.00	21.10
H3	33115	37.57	28.52	33.32	30.20
T-Mobile	33419	50.54	36.06	25.06	23.10

To statistically confirm these results, ECDF (empirical cumulative density functions) of the downlink speed results are shown in Figure 2 a), which shows the distribution of all measurements per operator and shows, that low-scored measurements do not differ per operator. The part of the measurements was negatively affected or corrupted in some way (low signal strength, handover, device limitation). To depict the average user experience, notice the top 50 percentile of the results. The best possible user experience per operator can be represented by the 98 percentiles. The Figure 2 b) shows the ECDF of the latency measurements, which shows A1 having the lowest latency in lower tail and T-Mobile at higher percentiles.

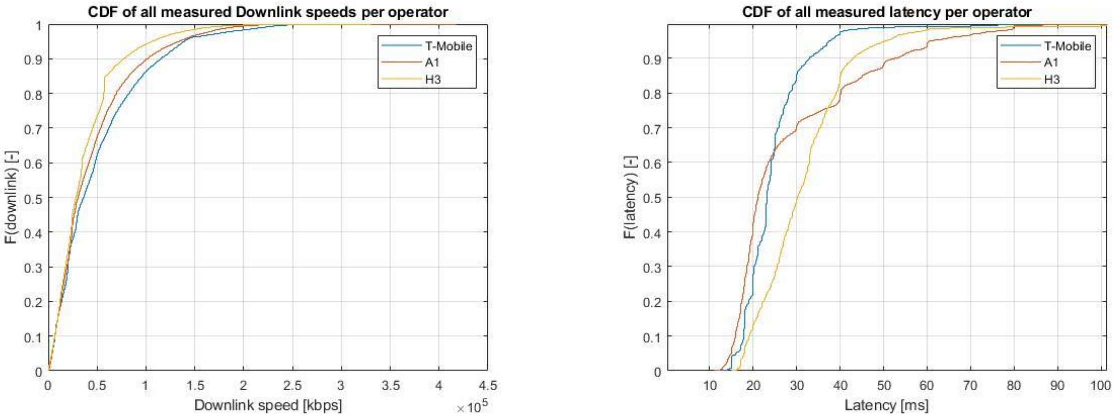

Figure 2: a) ECDF of all measured downlink speeds per operator; b) ECDF of all measured latency per operator

3.2 SPATIAL INFORMATION

The previous chapter presents some of the statistical quantities per operator without taking into consideration the place where the measurement took place. The next part of the analysis divides the considered region in Austria (e.g., Vienna) into spatial bins and finds out, whether the parameters of the network are consistent over the considered area. The similar technique was utilized in [4]. Using this type of analysis, the previous finding was modified and enriched with spatial information about which operator's network has the best parameters per area. The size of the bins was modified to include enough measurements per bin for assessing the network parameters reliably using Welch's t-test. Figure 3 a) and b) depicts Vienna, which has the most measurements per area in the Austria. It is apparent, that neither binning does provide enough samples per bin for t-testing to be realized without introducing a serious Type I error [5].

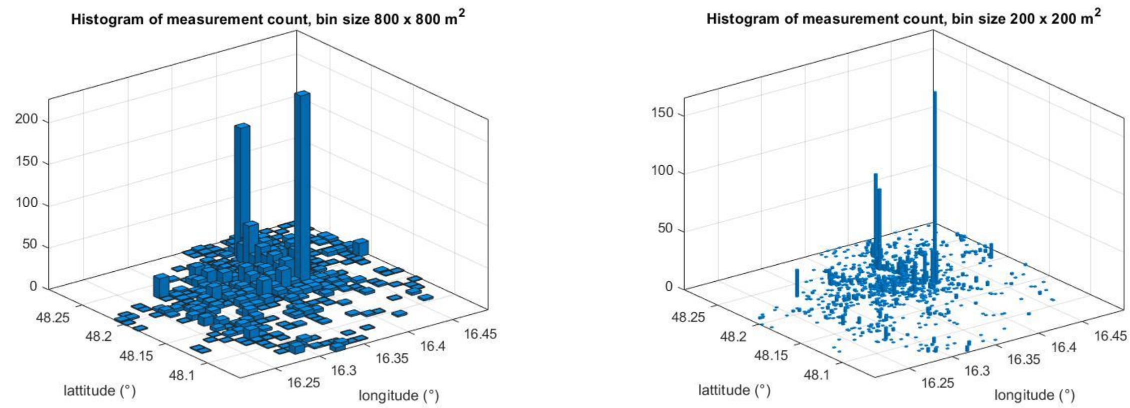

Figure 3: Binned area of Vienna showing the density of measurements per a) 800 x 800 meters^2 and b) 200 x 200 meters^2

The alternative approach is proposed using clustering techniques. The areas such as roads are not properly represented by squared bins, whereas clustering along the direction of the road will fix both problems that binning presents: choosing the appropriate length (for roads/rails) or areas (per city) for each cluster to contain enough measurements. Clustering Using Representatives (CURE) algorithm is implemented. CURE has the capability to cluster non-spherical variances and shapes [6], making it a preferable choice for this project.

The drive test will be performed to evaluate, whether the network performance parameters calculated using crowdsourced measurements provide reliable and accurate information.

The tool for monitoring the performance of the telecommunication nodes within each bin will be created to assess the performance in temporal region as well. Additionally, data is analysed in temporal region to assess the time-of-day dependency, showing the hourly distributions per operator.

4 CONCLUSION

In this paper, the data gathering technique called crowdsourcing has been presented. The measurements by RTR's NetzTest have been used as the primary source of data for the project, containing over 380000 entries for LTE networks in Austria in the year 2018. The data density is inconsistent in location, focusing around densely populated areas and along frequently used routes. The analysis per operator shows, that from three largest operators, the highest performance scores has T-Mobile for an average user (median or 50 percentile user) and in top-performance metric considering only top 2% of the results. The location analysis divides the space into bins and compares the results bin-wise to assess spatial information to the results, as well as clustering the areas using CURE algorithm. The drive tests will evaluate the results. As the next step, the correlation between bins and clustered will be analysed and temporal information will be added to the analysis.

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