SMARTPHONE-BASED CROWDSOURCING FOR MOBILE NETWORK BENCHMARKING

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INTRODUCTION

Crowdsourcing is a neologism coined as a portmanteau of *crowd* and *outsourcing* by Howe and defined as ”outsourcing a job traditionally performed by a designated agent to an undefined, generally large group of people in the form of an open call” [1] . The crowdsourcing paradigm is introduced to a plethora of disciplines, but its potential applications in telecommunications, in particular for the performance evaluation and benchmarking of mobile networks has not yet been fully explored. This research is specifically targeting at establishing such a framework.

MOBILE NETWORK BENCHMARKING

The state of the art in mobile network benchmarking is designated drive tests, for which the disadvantages are: consumption of significant amount of time and human effort, large operation expenditure, geographically limited data acquisition, and the requirement of off-line analysis. Smartphone-based crowdsourcing makes a viable alternative to conventional drive tests. The idea is for smartphones to operate as geolocalized sensors capable of monitoring the state of the access network *(passive)*, along with serving as measurement probes *(active)*. The common practice is for the devices to run a mobile application which, besides coordination with a designated server, can provide measurements of network-related properties such as data rate and delay. Figure 1 presents the generic structure of such a system.

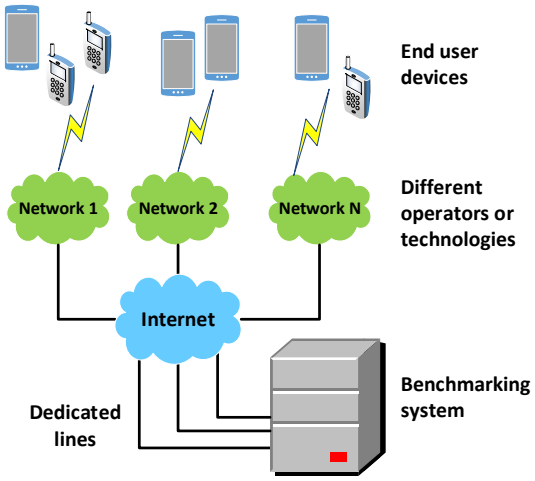

Figure 1: Crowdsourcing-based mobile network benchmarking system

RESULTS AND DISCUSSION

We focus on three main aspects: identification of the opportunities and challenges of crowdsourcing mobile network performance measurements, determining the necessary signal processing approaches and relevant metrics for translating user experience into an overall network performance, and identifying the properties of an ideal benchmarking system for accurate, fair and repeatable benchmarking.

Opportunities and Challenges

We identify the opportunities inherent to crowdsourcing as *”Power of the Crowds”* (simplification in operation), *Mobility and Ubiquity* (pervasiveness of smartphones), *Real-Time Operation*, *Cost Reduction*, and *Representation of Realistic User Performance*, where the challenges are *End-Device Related Issues* (unavailable parameters, unknown properties and personal usage), *Resource Consumption*, *Privacy versus Reliability*, *Incentive Mechanisms*, *Inaccuracy of Measurement Algorithms*, and

the challenges associated with determining *Network Performance from User Performance* [2].

User Performance to Network Performance

For fair benchmarking, it is essential to estimate the overall network performance from a large number of potentially tariff-limited users. This includes: a) employing machine learning algorithms to detect user profiles ("which users are tariff-limited, which are not?) from plots similar to Figure 2 through clustering, b) identifying measurement bottlenecks ("is there a tariff-limitation, network bottleneck, or server bottleneck?") [4], and c) finding the relevant metrics for baselining ("according to what reference value should the results be compared?").

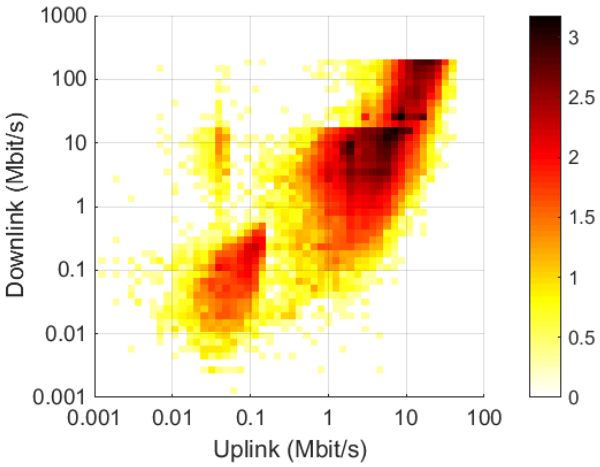

Figure 2: Reported data rates for all measurements in RTR Open Data [3] (one operator, 2014-2015, log10) [4]

Benchmarking System Requirements

We investigate the necessary design principles for crowdsourced benchmarking systems. For instance, Figure 3 shows the use of cumulative sum (CUMSUM) average as a time series analysis method to estimate a "good" average capable of discarding the ramp-up phase for TCP-based measurements, increasing the accuracy of the system's available data rate estimate. Similarly, conducting bottleneck analysis on an existing system, we show that appropriate request scheduling is of key importance for fair benchmarking [4].

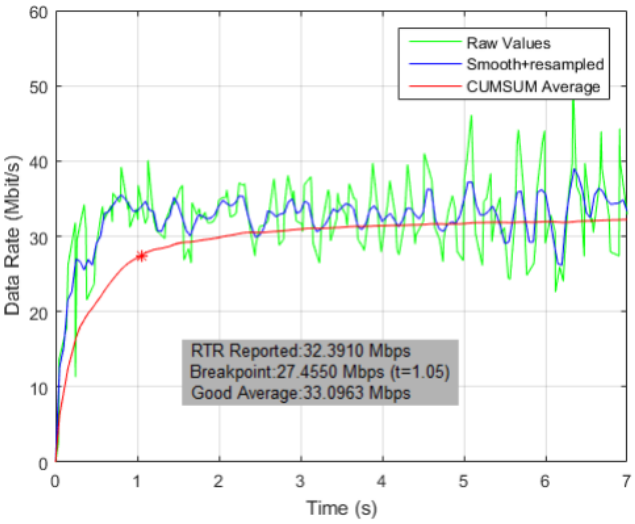

Figure 3: Time series for downlink data rate from a single measurement in RTR Open Data [2, 3]

CONCLUSION

We investigate the possibility of replacing conventional drive tests with crowdsourced network benchmarking and show that although there is a big potential, data collection has to be complemented with appropriate signal processing for fairness and accuracy. Future work includes cluster analysis and time series forecasting for estimating mobile network performance.

REFERENCES

[1] J. Howe, "Crowdsourcing: A definition." http://crowdsourcing.com/cs/2006/06/crowdsourcing_a.html

[2] C. Midoglu and P. Svoboda, "Opportunities and Challenges of Using Crowdsourced Measurements for Mobile Network Benchmarking A Case Study on RTR Open Data", *SAI Computing 2016* [accepted]

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[4] C. Midoglu, L. Wimmer, and P. Svoboda, "Server Link Load Modeling and Request Scheduling for Crowdsourcing-Based Benchmarking Systems", *IWCMC 2016* [accepted]