A Nationwide Study on Cellular Reliability: Measurement, Analysis, and Enhancements – *Public Review*

Lili Qiu
The University of Texas at Austin
Austin, TX
lili@cs.utexas.edu

Cellular networks have played a significant role in our daily life. As the cellular networks are transitioning to 5G, it is a great time to analyze cellular network performance and reliability. This paper conducts an in-depth study of cellular network reliability. The work is very timely and can inform future 5G deployment and beyond. It is by far the largest published cellular measurement study: it collects and analyzes data from 70+ million android phones over 34 different hardware models across 3 ISPs (China Mobile, China Telecom, China Unicom) with 5.3M base stations!

The paper has made several significant contributions. It first develops a useful tool to continuously monitor an Android system to detect cellular failures and record detailed device and network traces at the time of failures. Through detailed analyses, the authors report several surprising findings: (i) Failures are prevalent across both phone models and ISPs. (ii) Most failures are due to software reliability instead of hardware limitations. (iii) Reliability degrades as received signal strength (RSS) increases since high RSS scenarios tend to have dense base stations, which increases adjacent channel interference and LTE mobility management overhead.

Next the authors delve deeper into transitions between different cellular generations. In particular, they find that it is not always desirable to use 5G. In fact, certain 4G to 5G transitions (*e.g.*, 4G transitioning to 5G level 0) do not increase the data rate but only degrade the reliability due to less mature 5G implementation and high failures under level-0 RSS. Moreover, a similar pattern also exists in other transitions between cellular generations (*e.g.*, 2G to 3G level 0, 3G to 4G level 0). Therefore, they recommend avoid these transitions.

Then the authors examine the three-stage cellular-connection recovery in Android, which tries light, moderate, and heavy recovery schemes one by one based on a fixed timeout. They report that the fixed timeout incurs significant delay and inefficiency, and propose a dynamic trigger by estimating recovery probabilities for different time windows to speed up the recovery.

This paper is one of the highest ranked papers at SIGCOMM 2021. It sets an excellent example for a great measurement paper. All reviewers appreciate its in-depth analyses of large-scale cellular traces and its focus on a timely and exciting topic. Moreover, it goes beyond measurement & analyses by developing and deploying effective enhancements on millions of phones and showing significant improvement on these phones used by real users. The authors have also released code to the public.

This paper inspires the research community to explore several interesting directions for future research. For example, it is important to further examine the inter-operation among different cellular standards. While the selection of radio access technology (RAT) has been studied in the past, it is mainly for maximizing throughput. This paper shows that RAT selection also impacts reliability, and points out other factors that should be considered in designing RAT selection. Moreover, it is interesting to see that cellular reliability degrades as the RSS and base station density increase. The density of base stations has significant impact on network capacity, handoff delay, interference, and mobility management overhead. Therefore, it would be nice to automatically determine the desirable BS density that can balance these factors and optimize both performance and reliability. In addition, changing active probing to passive probing could help further reduce overhead and interference with the current environments.