Broadband Wireless Network Measurements Using Smartphones

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The problem: The end-user performance of a network is determined by both back-haul (wired) and front-haul (wireless) network systems. Most network measurement work today is focused on the wired internet. Characterizing wireless network performance has proven to be extremely difficult since operators closely guard their deployment data and making measurements using professional equipment like network analyzers is expensive and time-consuming for academic researchers. Hence, there is a growing need to develop tools and methods that will allow scalable, quick, and accurate measurements that will enable a better understanding of how broadband wireless networks perform and use this data to enhance performance. Furthermore, end-to-end measurements that include the wired and wireless internet are becoming increasingly important, especially as we look ahead to the 5G network architecture which will use features such as end-to-end network slicing along with new physical layer features such as mmWave beam-forming and mid-band Massive MIMO. How should one measure end-to-end throughput, latency, and other QoS parameters in these networks?

Challenges: Broadband wireless networks are rolling out rapidly across the country. Cellular operators routinely aggregate a number of channels in different frequency bands, including the unlicensed 5 GHz bands and most recently the CBRS band and 6 GHz in the near future. mmWave cellular deployments are also increasing, especially in dense urban areas. Our previous work [1], focused on the coexistence of 4G Licensed Assisted Access (LAA) deployments in Chicago with Wi-Fi in the unlicensed spectrum, made use of Android smartphones with commercial and self-developed apps to measure and evaluate coexistence behavior. Recently, we have expanded this effort to measuring 5G New Radio (NR) millimeter wave (mmWave) deployments in Chicago. In both cases, we require detailed real-time information of the physical layer of the cellular network: signal-to-interference-and-noise ratio (SINR), block error rate (BLER), modulation, coding rate, number of allocated resource blocks (RBs), transmission opportunity (TXOP), MIMO configuration, PHY layer throughput, beam index, etc., all of which contribute to a more complete understanding of how cellular networks operate and help answer specific research questions such as: (i) how does LAA perform when coexisting with Wi-Fi on a hidden node scenario? (ii) how efficient is 5G mmWave beam management when channel conditions fluctuate? (ii) how can one optimize carrier aggregation across different bands? etc. To truly understand the wireless performance of 5G and next-generation wireless networks, the research community needs to develop better tools, methodologies, and data-sharing platforms.

Multiple tools exist today. Prof. Chunyi Peng from Purdue University has developed MobileInsight [2], which allows users to capture some of the PHY, MAC, and RLC layer features of 4G and 5G networks. Prof. Zhi-Li Zhang from the University of Minnesota has developed a 5G-NR tool to capture high-level parameters such as velocity, angle of panel direction, throughput for the 5G mmWave system [3]. We, at the University of Chicago, have developed an Android app called SigCap [1], which is capable of continually capturing basic information without using root access, for instance, 4G LTE RSRP, 5G RSRP, bandwidth, frequency, PCI, etc. These tools have been developed with specific research questions in mind, and are thus individually limited in scope. For example, we cannot use MobileInsight for our work due to its focus only on MAC and RLC layer. The 5G-NR tool of the University of Minnesota only measures the application layer and does not support the PHY layer. Our SigCap tool only captures the basic information of the PHY layer. Commercial tools such as Network Signal Guru deliver detailed information, but are associated with monthly fees and require professional software not available to academics for data export and analysis.

Solutions: Smartphones today have become the new network analyzer. Increased processing and memory capacities within modern smartphones now allow for a greater opportunity to process and present network configuration data to the user that had not been possible in the past. Using apps that exploit APIs that are available on Android phones, one can extract network information that in the past was only available with extremely expensive test equipment. However, most of the tools available today only provide rudimentary measures of network performance. There is a need for the research community, supported by NSF, to develop such open-source tools and data-sharing platforms that will enable continuous measurements of broadband wireless networks. These tools will need to evolve to provide more detailed information with respect to network configuration (bands, channel bandwidth, beam configurations, etc.) and performance. This effort would also greatly benefit from industry participation and collaboration since the most useful tools require in-depth knowledge of the wireless chipsets being used in phones. Industry, both wireless chip-set manufacturers and cellular carriers, would benefit in turn from the "crowdsourcing" of network performance data that would be enabled if these tools became widely available to academic researchers around the country: this data would help industry design better devices and optimize network management. Smartphone crowdsourced detailed measurement capabilities available to researchers and "volunteer" testers will provide the opportunity for broad based testing across a wide set of geographies. This network performance data today is usually gathered by drive-testing that the carriers undertake: this is expensive, cannot be done continually, and most importantly, is not available easily to academic researchers.

Therefore, we believe that an open smartphone-based framework to measure, curate, and make available the detailed parameters of cellular networks is extremely important for academic researchers to remain at the forefront of innovation in broadband wireless networks. Smartphone-based tools will democratize the capability to make wireless network measurements.

References:

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