NETWORK TESTING AND ANALYTICS


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User-centric quality of experience (QoE) measurement has been attracting attention as a complement to existing network-centric measurement. Understanding the correlation between network quality of service (QoS) metrics and the user perceived QoE can drive improvement in service quality of each service and application offered (video/audio streaming, conferencing, etc.). Predictive analytics, increasingly powered by machine learning methods, is playing a large role in this area. We have also seen the proliferation of open measurement platforms and testbeds, spanning real commercial networks, empowering large-scale experiments and profiling of novel protocols and services. These enable performance evaluation of applications, and network and transport protocols in a real operational setting under a diverse set of workloads and conditions.

For this March issue, we accepted three articles from 12 submissions after a thorough review process. These articles feature developments in all the above-mentioned areas, from field tests and analysis of emerging protocols utilizing large-scale measurement platforms to a QoE inference framework for popular Internet applications (e.g., YouTube) in home networks via remotely collected network QoS metrics.

The first article, "On the Use of TCP BBR in Cellular Networks," evaluates different transport protocol configurations in real commercial networks and an emulated testbed. The Transport Control Protocol (TCP), which carries about 90 percent of all Internet traffic, comes in many flavors, which mainly differ in the details of their congestion control algorithms (CCAs). New CCAs are being developed in response to the evolution of technology (e.g., higher speed, wireless access) and services (e.g., high-resolution graphics, animation). One of the most recent CCAs is Google's Bottleneck Bandwidth and Round-trip propagation time (BBR), which in many ways is conceptually different from predecessors like CUBIC and NewReno. E. Atxutegi *et al.* extend earlier studies of BBR to cellular networks by experimenting with fixed users in three operational 4G networks and moving users in emulated approximations of 4G and 5G networks. Compared to CUBIC and NewReno, the first set of measurements shows that BBR overall manages to combine high throughput with low queuing delay, cutting the median queuing delay roughly in half when the available bandwidth is low, but that BBR impedes performance for competing short flows when the bottleneck queue is small. The second set of measurements shows that BBR struggles to track the changing channel characteristics under 4G delays but not under 5G delays, although this relief may not suffice to handle the full-scale variations of 5G channels.

In the second article, "Measuring ECN++: Good News for ++, Bad News for ECN over Mobile," A.M. Mandalari *et.al.* conduct an extensive field measurement campaign to analyze the feasibility of ECN++ deployment, an experimental extension to the Explicit Congestion Notification (ECN) protocol, adding ECN marking to TCP control packets and retransmissions. The authors profile ECN and ECN ++ support in both fixed and mobile networks, exploring a dataset containing more than 26 million end-to-end communications and testing 6.5 million different paths. They show that ECN marking does not cause packet drops, this being true for data packets (regular ECN) as well as TCP control packets and retransmissions (ECN++). In particular, no case was found where adding the ECN capability to a SYN increased the likelihood of connection establishment failure. However, while ECN marked packets traverse fixed networks successfully, more than half of the 18 mobile carriers tested routinely wipe the ECN field of all packets from the mobile clients toward the rest of the Internet. This behavior was observed for data packets, as well as for TCP control packets and retransmissions. The authors also measured the response to the ECN congestion signal, finding that all the ECN-capable top-500k Alexa servers have the same response to ECE as to 3 DupACKs, and at least 51 percent of the Alexa top-500k servers support IW of 10 segments.

Communication service providers are doubling down on their effort to assess and evaluate the QoE of end users in home Wi-Fi networks in an accurate and automated manner. Flawless experience of video streaming services is becoming of paramount importance to customer satisfaction. To this end, the final article of this issue is focused on new solutions that will unlock QoE inference for video services in home Wi-Fi networks by means of network analytics. A. Ligata *et al.*, in "Quality-of-Experience Inference for Video Services in Home Wi-Fi Networks," present a framework that showcases a machine learning powered process of building a mapping function between remotely accessible network QoS parameters and QoE indicators for video services. The article details Wi-Fi-specific problems and the interplay between different network scenarios, feature engineering, and data modeling. The authors demonstrate high prediction accuracy (85–95 percent) for the proposed framework through a case study of YouTube service under varying Wi-Fi network conditions. Further guidelines on the implementation and deployment of the proposed solution are also provided.

BIOGRAPHIES

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IRENA ATOV [SM] (i.atov@ieee.org) received her Ph.D. in electrical engineering from RMIT University, Australia, in 2003. She is currently principal architect at Microsoft in their Skype for Business Core Engineering Group. Previously, she has worked in academia in both teaching and research roles, consulted for industry through her own company, and worked for Telstra in Melbourne, Australia, as program director of Network Analytics and Resilience. Her research has led to development of several commercial IT software products.

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