

Tracking Quality-of-Experience on the Internet

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Engineering interests at the FCC in connection with Quality of Experience on the Internet include the following:

- i. Quality of Experience (QoE) attributes of Internet services, and working definitions/measures of QoE for different applications
- ii. Correlations of QoE metrics with observable network performance characteristics
- iii. Emerging network measurement techniques, and key infrastructural capabilities that could assist with investigating/tracking the factors mentioned above. Examples of the types of questions answers are sought for are
 - o Can repetitive routine measurements on network measurement infrastructures contribute to assessing the QoE being experienced, and if yes, what specific measurements would be instrumental in getting this view of QoE?
 - o Could these measurements be supplemented via cooperative, correlating measurements taken by the components in the network architecture itself (content servers in the CDN, routers, switches) and if so, how?
 - o Approaches, including heuristics, for achieving measurements, given the increased prevalence of encrypted traffic
- iv. Context-specific, or service-semantic-sensitive measurements: certain community sectors may be dependent on a set of network services with shared attributes. Measurements to do with these services would be more pertinent if they could identify and focus on the service-specific network properties that particularly impact those services (for example, paths).

There is excellent work underway in the field of Internet measurements, with significant advances owed to a dedicated community of research and industry leaders, several of whom have pioneered and led continuing explorations over decades. This has resulted in a useful diversity of focus and approaches. Since Internet technology increasingly constitutes the principal infrastructure for everything from entertainment, to telecommunications and critical services, it is worth reviewing existing and emerging scientific efforts in measurements and allied analytical, and 'human factors' fields, to better understand not merely the technical ground truths, but whether, and where, collaboration or complementary differentiation of research efforts in future may help.

The result desired is that, as a diverse technical community, we take steps to emerge collectively better informed about existing research /industry baselines, so as to be able to posit optimal steps towards the goals articulated in the workshop's statement of purpose ie, to begin to identify future directions in collaborative or differentiated, but complementary work. The types of answers or solutions it is hoped will eventually result, include contributions in the following areas:

1. How best to define and measure QoE. Measurements will need to be application-centric and consider evolving network design and its impacts. For example, any or all of the following could influence application throughput and latencies: Middleboxes, CDN strategies, SDN instantiations, IPv6 deployment, TCP optimizations.
2. Understanding how to relate QoE to parametrically or functionally identifiable network attributes, including those that would help with the localization of source of problems and how to put network

performance in the context of the architectural environment it is associated with-such as CDN adjuncts, or CDN overlay-specific TCP enhancements.

3. Strategies for consistent measurement of QoE and allied network properties. Measurements approaches are either infrastructural (ie utilizing a purpose-built network specifically for measurement, using an overlay and embedded measurement devices), or user -initiated /crowd-sourced through measurement clients run on demand. In either case, it may be useful to explore whether some measurements can intrinsically be federated (e.g. the practicality or usefulness of composing end-end metrics from constituent measurements undertaken by different entities).
4. Support for resource-constrained, yet adaptable and secure measurement platforms, and the roles of emerging research or standardized measurements infrastructures.
5. Heuristics for measuring QoE and factors that influence it in encrypted scenarios.

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