

In-Situ Quality of Experience Monitoring: The Case for Prioritizing Coverage Over Fidelity

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The Internet today is largely an *eyeball economy*, which is driven by revenue streams that depend crucially on user-perceived application experience [1, 4, 10]. There is an increasing realization of this in the broader networking community. This is evidenced by the trends in papers in conferences (e.g., [4, 6, 11, 13]), workshops explicitly aimed at looking at performance moving up the stack and focusing on human-centric experience (e.g., [2, 3]), and many parallel industry efforts at leading content providers and content distribution companies [7, 10].

A natural requirement for different stakeholders in this eyeball economy is to optimize end user quality of experience (QoE) for different applications such as web, video, voice, and so on. A fundamental requirement that we need to address even before we embark on developing systems and architectures for optimizing QoE, is to develop a principled approach for *measuring and understanding* QoE.

At a high level, one can consider two contrasting approaches to measure and understand QoE. The first approach takes a tried-and-tested approach in the networking literature—deploy active probe vantage points and measure key network-centric measurements in controlled conditions to provide detailed and in-depth measurements. This is an approach that has really served us well in the past, as evidenced by the success of large-scale measurement platforms such as PlanetLab, FCC MBA, iPlane, among others. A second approach is an “in situ” measurement that relies on already deployed applications to measure the application-level performance in the wild, but possibly compromising on the fidelity of the measurements (e.g., due to constraints on the client platforms) and on control over measurement parameters.

In this whitepaper, we argue that it is time for us to focus more of the community efforts on this in-situ approach in contrast to conventional controlled measurement platforms. We observe several technical and pragmatic reasons that naturally make this case:

- First, we see a growing diversity in application usage patterns and the types of platforms and providers from which Internet applications are being consumed in the wild. Doing a controlled experiment that can account for all possible settings will incur a combinatorial explosion of configuration parameters we need to test.

- Second, we observe that several key ecosystem players today already have extensive and widely deployed client-side instrumentation to collect application-level quality measurements [6, 10].
- Finally, we believe that we can harness the “unreasonable effectiveness of data” [8] to help compensate for the lack of fidelity and control, by simply increasing the coverage and scale of the data at our disposal.

Case study – Building an Internet Map: Many Internet applications can benefit from a service that provides a real-time *traffic map* of the Internet [5, 12]. For instance, CDNs could improve server selection, websites can be optimized to customize content for their clients based on the network state. However, this vision has been tantalizingly out of our reach. In this context, we observe that the growing volume of Internet video traffic and the ability to instrument video players to measure performance of video sessions in near real-time [6, 10] offer an unprecedented opportunity to address the above challenges. Specifically, we have (perhaps for the first time) the capability to obtain real-time measurements of the network state from millions of vantage points without any additional probing overhead.

We can leverage this opportunity of using video traffic as the “carrier signal” to generate a real-time traffic map. We envision one or more providers in the video ecosystem who can offer such a service.

Case study – Federated Optimization Architecture: Network infrastructure owners (i.e., ISPs) and application providers have traditionally not been coordinated with optimizing user experience, leading to repeated tussles between content providers and ISPs. In addition, application providers commonly deploy complex workarounds that reverse engineer the network’s impact on application-level metrics. Ubiquitous client-side measurement of QoE is a key enabler for a new network paradigm where application providers and network providers collaborate meaningfully to improve QoE [9]. In addition to QoE measurement, we observe two parallel technology trends that are enablers for this architecture: the emergence of novel “big data” platforms for real-time analytics, and new control plane capabilities for ISPs (e.g., SDN, IXPs, NFV).

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