What's Ahead For Quality-Of-Service Measurements?

Yaakov Stein
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Yaakov (J) Stein is CTO at Allot.

When asked, "Who invented the telephone?" most people have no problem answering Alexander Graham Bell. Maybe they'll even remember his assistant, Thomas Watson (as in "Mr. Watson, come here. I need you.").

But who's the father of telephone *service*? That honor goes to Theodore Newton Vail.

Theodore was a cousin of Alfred Vail, co-inventor of the telegraph. Before becoming the first CEO of Bell Telephone, Theodore Vail was general superintendent of the U.S. Railway Mail Service. Bell's father-in-law and angel investor, Gardiner Hubbard, offered Vail the top Bell telephone job due to the vision he had of interconnecting all telephones.

You see, Bell and his assistant, Watson, never got past the stage of offering pairs of telephones for sale. A pair of telephones is a very useful *product* but one with a major drawback. You need a pair of telephones for every pair of locations you wish to interconnect.

Vail, on the other hand, understood that telephony needed to be organized as a *network* (through which anyone can contact anyone else) and just as crucially packaged as a *service* (like the postal service from which he came). In fact, the term *Vailism* is used to describe the philosophy that such public services are best run as regulated monopolies.

Communications Products Vs. Services

In what we'll call here the *Bell-Watson model*, the customer pays once for a *product* but is responsible for installation (e.g., wiring up the telephone and connecting the battery) and maintenance (e.g., replacing the battery and repairing wires). Under this model, the Bell Telephone Company would only be responsible for providing functioning telephones.

In the *Vail model*, the customer pays a monthly fee for telephony *service,* and the service provider assumes responsibility for operations. Nowadays, it seems like everything related to "computications" has become a service: software as a service (SaaS), platform as a service (PaaS), infrastructure as a service (IaaS), data as a service (DaaS), content as a service (CaaS) and just about anything as a service (XaaS).

Why we're willing to pay for products is intuitive, but why are consumers willing to pay for services? After all, the marginal cost to provide a service is often negligible.

Free Services

Do you conference over Zoom, Skype or WhatsApp? Do you email using Gmail? Do you watch YouTube or TikTok? Do you have a profile on Facebook or LinkedIn? Ever transfer files using Dropbox? Do you use Google search? Have you ever used free Wi-Fi?

All these services are essentially free (although some may have for-pay versions, and most display ads to cover costs). If you can get all these for free, why does *anyone* pay for *any* service?

The answer is simply that people no longer pay for basic communications services (which can often be obtained free of charge). Instead, they pay for quality-of-service (QoS) guarantees. Put simply, consumers pay for the right to complain when the service quality doesn't meet expectations.

QoE

If we pay for the right to complain about a service's quality, then this quality must be something that the customer directly *experiences*.

One definition of the quality of experience (QoE) is the "overall acceptability of an application or service, as perceived subjectively by the end-user." QoE is thus a psychophysical measure, which can be quantified only using human subjects. The most popular measure is the mean opinion score (MOS), which is measured by averaging the opinions of multiple subjects, each providing a score on a scale from 1 (bad) to 5 (excellent). The MOS for the speech quality of modern conferencing applications is close to 5, landline telephones score 4 and 2G/3G cellular phones score about 3.6. If, after a video conference call, you're asked to rate the call from 1 to 5 stars, you're actually participating in a large-scale MOS test.

QoS And Its Demise

But subjective measures may be very slow and expensive to quantify in communications settings. For simplicity, the leading method of defining service quality hasn't been QoE but rather something deceptively called the quality of service (QoS). QoS parameters are easily measured objective measures of communications channels that are believed to have *some* correlation with QoE and can be used as proxies for the true QoE. Commonly used QoS parameters include service availability (measured in nines; e.g., five nines equals 99.999%), signal-to-noise ratio, information latency and packet loss ratio.

Over the past decades, this QoS and QoE connection has been vindicated. Many explicit formulas have been developed connecting network QoS with QoE degradation for various applications, such as telephony, video streaming, video conferencing and general browsing.

However, these formulas may fail to hold for many modern communications scenarios. For example, firewalls, content delivery networks, WAN optimization and even dynamic webpages may potentially break any relationship between QoS and QoE.

This isn't a trivial issue. Without QoE visibility, network operators can't detect problems and take aversive action before disgruntled customers bombard their customer service lines (or simply leave for a competitor).

What Can Be Done?

Most ISPs are driven by customer input and upgrade oversubscribed resources as required. Such tactics may be good enough for best-effort services but don't suffice for critical infrastructures and services.

In many cases, readily measurable QoS parameters still have some predictive power, even when conventional empirical QoE formulas are no longer guaranteed to hold. In such cases, more sophisticated predictors may be derived by using additional inputs and exploiting machine learning techniques.

A more radical approach is to disavow QoS entirely and rely instead on end-user applications that directly determine QoE and report degradations to the network (with appropriate measures to maintain privacy and authentication mechanisms to avoid new cyberattack vectors). This *may* be the future of communications service-level maintenance, but it's still over the horizon.