WHITE PAPER

# Measuring Video Quality and Performance: Best Practices

Video delivery performance directly impacts the quality of a viewer's experience – which has a direct impact on business outcome.

Akamai

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## Measuring Video Quality and Performance: Why It Matters

Video quality and performance directly impact a viewer's quality of experience, which directly impacts media organizations' business outcomes.

In this white paper, we will provide an understanding of the video quality metrics, methodology, and measurement tools, as well as some of the best practices in designing a video quality and performance measurement framework that will help your organization improve viewer experience, retain viewership, and ensure that your services can stand up to increasing competition.

> "As the online delivery of video matures, so does the requirement to qualitatively measure the service, performance, and experience delivered to the end user. No system can be improved if it cannot be measured. The generation of metrics at each stage of the video delivery value chain, combined with a feedback and monitoring system, allows OTT service providers to evolve from a best-effort implementation model to a quality-assured, finely tuned, and robust entertainment distribution system."
>
> – Will Law, Chief Architect, Akamai

### Defining the Success of Digital Video Providers Through Viewer Experience

Meeting viewers' quality expectations as digital video consumption is going mainstream is an important success factor for service providers. There is a higher likelihood of churn if your service doesn't provide a better or comparable experience. This section covers the importance of certain video streaming attributes, the impact of quality, and key findings from recent research.

#### Meeting Viewers' Quality Expectations

The U.S. Census Bureau estimates that by 2023, the world's population will near 8 billion, and digital video viewership will rise more than 39%, from 35% in 2019.[1]

Digital video viewership is on an aggressive growth course globally. Countries like India and China have relatively low broadband penetration, but high rates of mobile usage for online video consumption. On the other hand, Western markets, including the United States and parts of Western Europe, see a strong penetration of connected TV infrastructures.

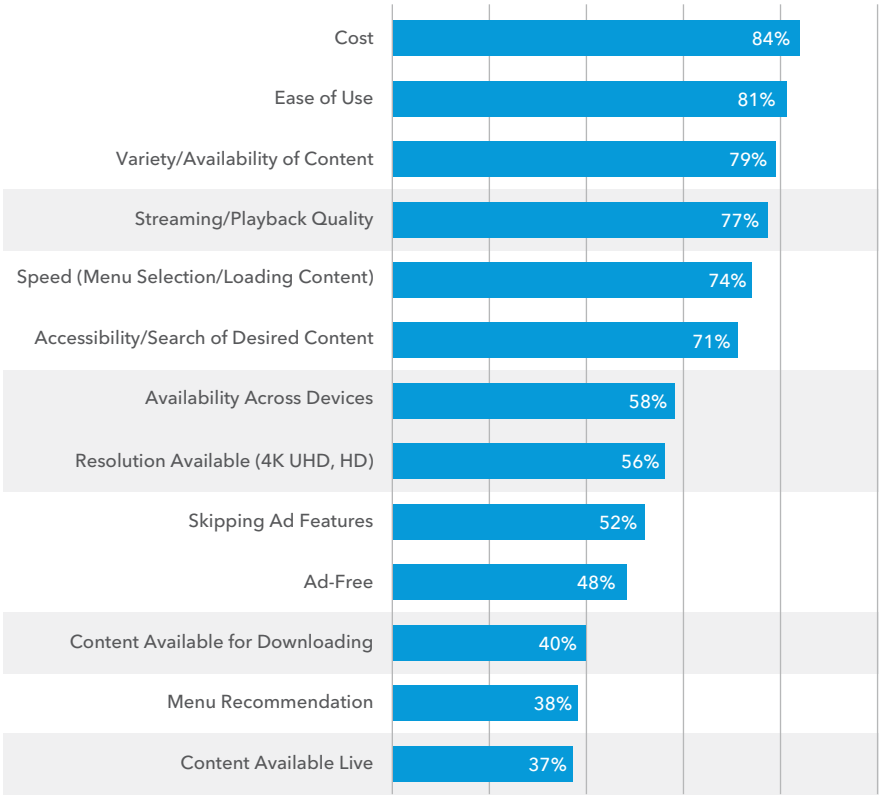
Increased video streaming choices and the low cost of switching providers are leading viewers to churn if the viewing experience is poor. With over-the-top (OTT) media services rapidly becoming a key part of digital entertainment globally, viewers expect high-quality experiences.

According to a **survey conducted by PwC** in October 2019 involving more than 2,000 people in the United States from ages 18 to 59 years, "streamlining the streaming experience" is increasingly important. Ease of use and reliability are linked to engagement, and are essential for driving retention and preference among video services.

The February 2020 edition of the **Nielsen Total Audience Report** highlights the importance of streaming and playback quality when it comes to the importance of video streaming attributes.

The chart below shows the importance of video streaming attributes, and the highlighted boxes show which attributes are affected by the content delivery network (CDN) platform being used for video delivery.

**Importance of Video Streaming Attributes**
(Rated Extremely or Very Important)[2]




## How Video Quality Impacts Engagement

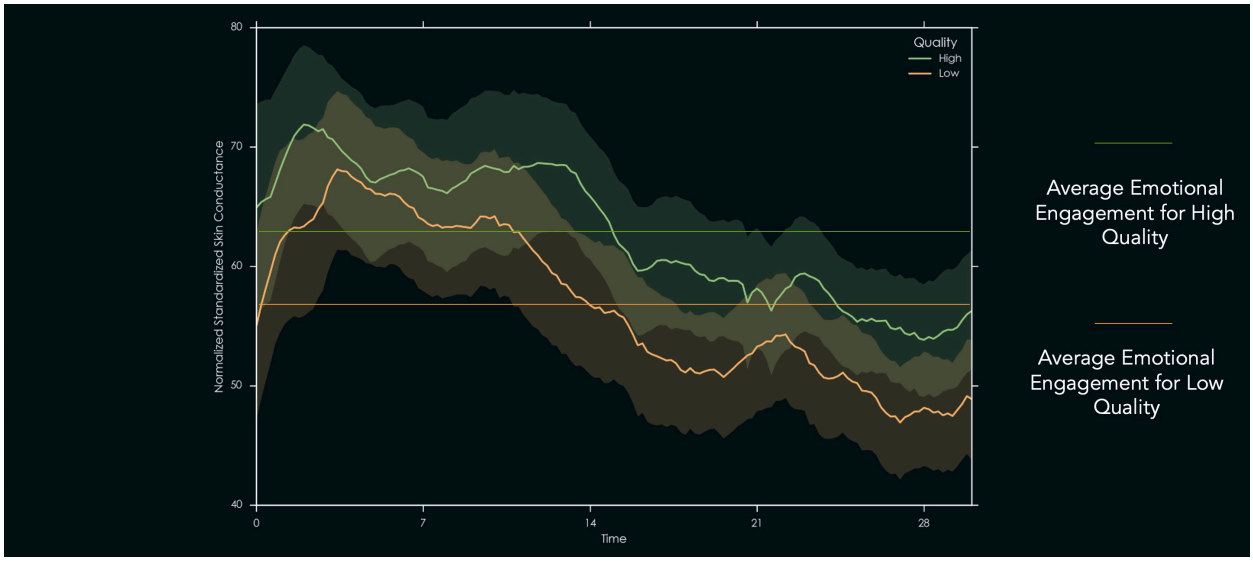
The primary business objective for most OTT service providers is to grow and retain their audience over a given period to ensure a return on investment (ROI). The quality of experience on a platform impacts a viewer's perception and engagement with the brand, which impacts the overall business model.

In order to clearly understand viewer behavior and its correlation to video quality, Akamai and Sensum,[3] a biometric research firm, measured the reactions of more than 1,000 people. Respondents were divided into two groups. One group was shown a video clip delivered at a high resolution (2160p UHD video, streamed at 5 Mbps) with no rebuffering. The second group was shown the same video at a lower resolution (1080p HD video, streamed at 1.6 Mbps) with a rebuffering event during a key scene. The reactions to both videos were measured using tools like galvanic skin response monitors and facial coding software.

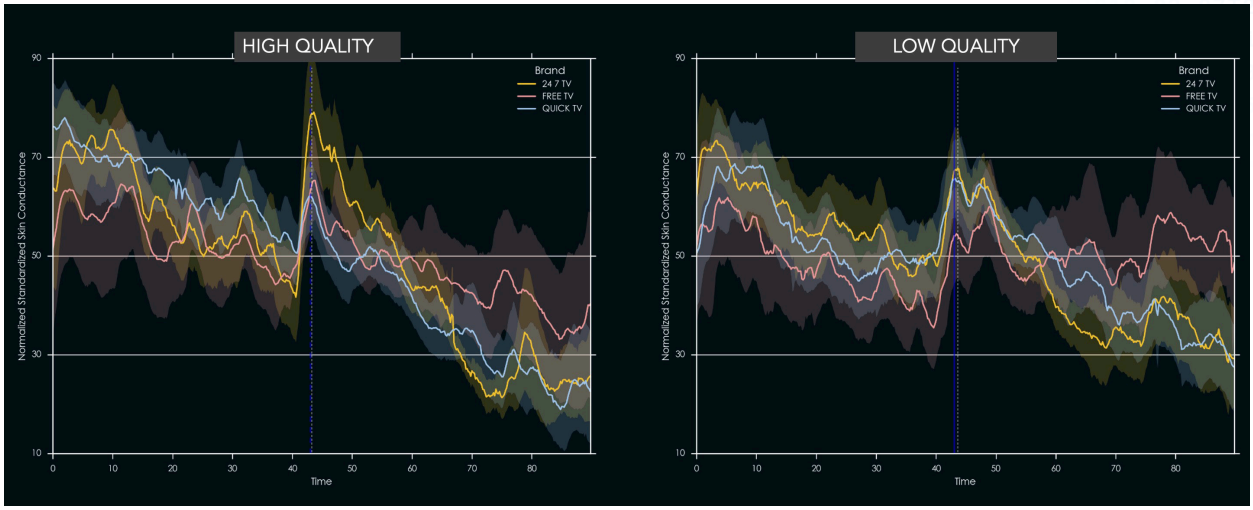
### Key Findings

- Higher-quality streams generated **19.8%** more emotional engagement according to the galvanic skin response test results
- Rebuffering caused a **16%** increase in negative emotions, **9%** increase in disgust, **7%** increase in sadness, and **8%** decrease in focus, according to facial coding technique results
- **76%** of participants would stop using a service if a problem like rebuffering occurred several times, according to survey responses

In the first test (graph below), respondents were asked to watch the high- and low-quality videos while their emotional engagement was measured. With no intense action, the higher-quality resolution video produced a 10.4% increase in viewer engagement compared with the lower-quality resolution according to the galvanic skin response results.



In a second test, in addition to the high- and low-quality videos, a two-second rebuffering event was introduced during a high-intensity scene. When participants viewed the action scene, there was a spike in skin conductance that you can see reflected in the graph below. In this moment of high intensity, when the action scene was introduced, the difference in viewer engagement between the high- and low-quality video was 19.8%. The secondary bump at 0:46 in the low-quality experience was most likely due to a moment of negative response to the rebuffering period.




## Creating a Robust Video Quality and Performance Measurement Strategy

Video delivery performance directly impacts a viewer's quality of experience, which directly impacts the video service provider's desired business outcome.

| Delivery Performance | | Quality of Experience | | Business Outcomes |
|---|---|---|---|---|
| Measures Video Delivery Quality | | Measures Users' Viewing Experience | | Measures Business Results |
| Can the video be delivered to the end users flawlessly without any issues? | Impacts | Can viewers enjoy a consistent and high-quality experience without interruptions? | Impacts | Would the viewing experience result in increased viewership, watch time, and revenues? |

"Is there a link between video quality and user retention? Probably so. When we first started, the number 1 reason for churn, according to customers, was because of video quality and rebuffering. That has now improved by 90%. As we improved, it went from the number 1 problem to immaterial."

– COO, SVOD Service

There is much debate about what metrics to use to define a user's viewing experience. Each aspect of digital video delivery (components within the online video delivery value chain, from content production to distribution) is measured differently, adding even more complexity to defining the video delivery performance and viewing experience.

For example, in a livestreaming workflow, the performance of the video preparation solutions is determined by how reliably and efficiently the video is prepared. For the distribution solutions including the CDN platform, performance is defined by the availability, scalability, and reliability of the platform.

Without consistency in measurements across video streaming services, it is difficult to standardize acceptable measurements. For example, there can be multiple interpretations to the statement "Rebuffering rate of 5%":

- Does this mean the average viewer spent 5% of viewing time experiencing rebuffering?
- Did 5% of viewers have at least one rebuffer event?
- Was this calculated as a mean or median value?
- How long does a rebuffer event need to exist for it to be counted?

There have been efforts underway globally to standardize measurements to examine streaming quality. The Customer Technology Association (CTA) established the R04 WG20 working group that recently published the streaming quality of experience events, properties, and metrics standard as **CTA-2066**. The standard specifies a set of media player events, properties, quality of experience (QoE) metrics, and associated terminology for representing the streaming quality of experience across systems, media players, and analytics vendors.

## Creating a Common Language for Measuring Video Quality and Performance

The first step toward standardization is to determine what the metrics are, what the methodology is, and what kind of measurement tools should be used to ensure transparency and consistency in measuring video quality and performance.

### Metrics

Define a common language of METRICS for measuring streaming quality and performance that customers can relate to

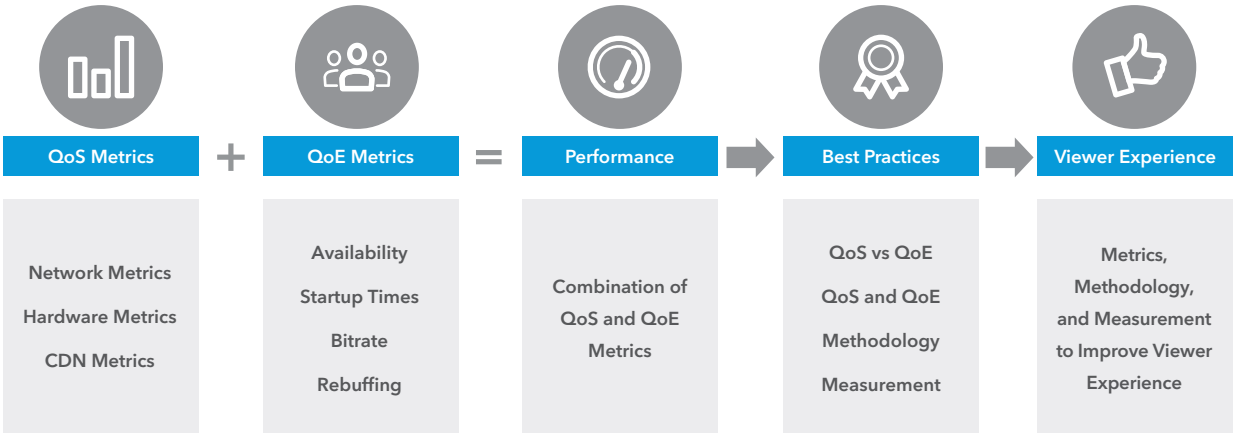
### Methodology

Objectively measure streaming QoS using a documented METHODOLOGY to ensure consistency

### Measurement

Quantitatively measure video delivery performance with tools that provide the required insights and granularity of MEASUREMENT

Let's begin by walking through what defines the viewer experience.




The viewer experience journey starts with identifying two major aspects:

1. A viewer's perception about the video quality determined by their viewing experience on their device – represented by QoE metrics
2. The service and performance quality delivered by the components in the video delivery value chain – represented by QoS metrics

### Quality of Experience (QoE) Metrics

> "Quality of experience is the degree of delight or annoyance of the user of an application or service. It is a measure of the perceived improvement or degradation of the audio or video and the viewers' satisfaction with the media experience."
>
> – Customer Technology Association (CTA)

QoE metrics are the parameters that determine the viewer's experience and perception of the service quality measured on the client device. Refer to the **Appendix Table 1** for some of the common QoE metrics measured by most video analytics services.

Although these listed metrics are the ones provided by most analytics tools, the methodology used to define them often varies, which can create inconsistencies in measurements and reporting.

For example, rebuffering is measured by different analytics tools using different formulas. They can be represented either as rebuffering count, rebuffering duration, or rebuffering frequency as mean, median, count, minutes, or percentages. The methodology varies based on how and when the rebuffering events are captured. **Appendix Table 2** represents some of the common rebuffering metrics and their definitions at a broad level.

### Quality of Service (QoS) Metrics

QoS metrics are parameters used to define the service quality of each component of the video delivery value chain (i.e., content preparation, production, processing systems, content distribution systems, and internet service providers [ISPs] involved in last-mile delivery to the client device).

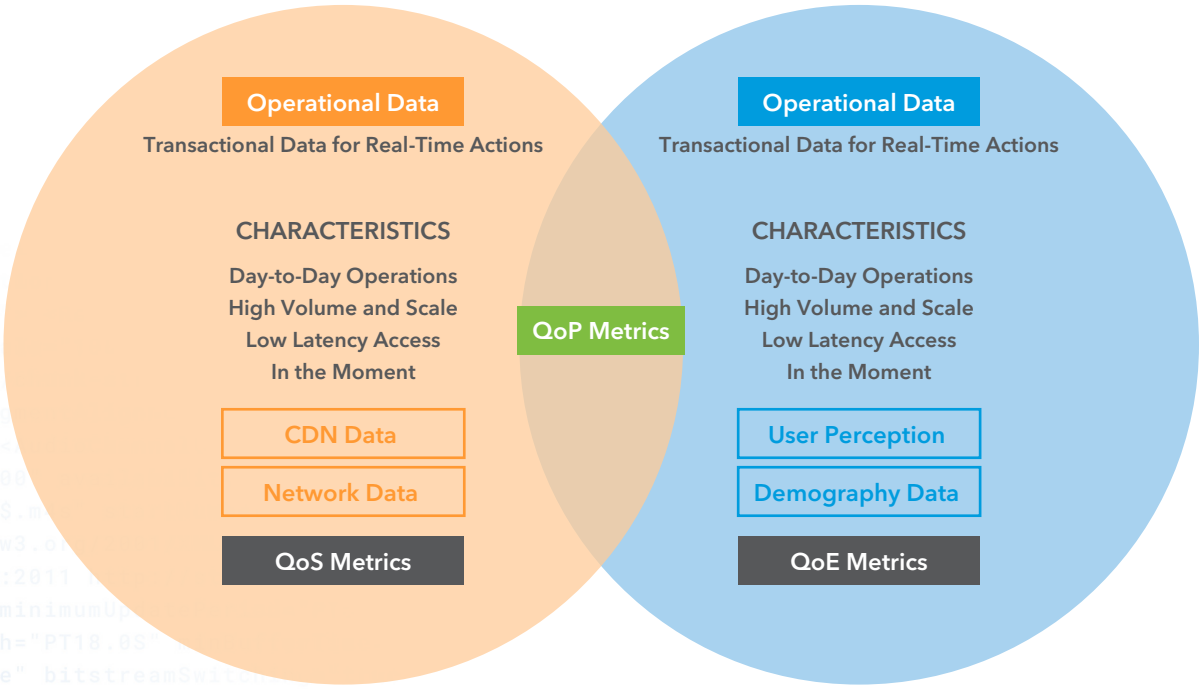
In order to overcome the QoE inconsistencies and to accurately pinpoint the source of degradation in performance, QoS metrics must be defined for each component of the video delivery value chain, including the content preparation infrastructure, the CDN, and the viewer's ISP.

QoS can be defined as "the description or measurement of the overall performance of a service, such as a telephony or computer network or a cloud computing service. To quantitatively measure quality of service, several related aspects of the network service are often considered, such as availability, throughput, transmission delay, jitter, etc."[4]

For example, when it comes to the CDN component of the video delivery value chain, it's important to understand the QoS metrics for a CDN. **Appendix Table 3** provides some of the common QoS metrics used to measure CDN performance.

### Quality of Performance (QoP) Metrics

QoS metrics are often characterized as operational metrics, or transactional data points mainly used for real-time decision-making, which differentiates them from QoE metrics, which are characterized as business metrics mainly used for effective decision-making.



Ensuring a unified view of the viewer experience across business and operations teams requires a unique set of metrics that provide the QoS for the respective component of the video delivery value chain and closely relate to the industry metrics for measuring quality of experience.

QoP metrics are parameters that can be used to define operational data to improve system efficiencies and provide visibility into the business aspects by serving as proxy QoE metrics.

**An example of a QoP metric:** In an adaptive bitrate streaming scenario, if a customer has video segments that are six seconds long and the CDN takes more than six seconds to deliver the segment, there will be rebuffering on the client player. A QoP metric can be used to measure this CDN service quality behavior and also serve as a proxy metric to client-side rebuffering.

**Best Practice:** Define effective quality of performance (QoP) metrics working with your video technology service provider to create consistent metrics that provide visibility into the quality of service (QoS) and also relate to the viewers' quality of experience (QoE).

## Using the Best Methodology to Measure Streaming Quality

Since OTT services and other digital video applications rely on multiple purpose-built solutions across the video delivery value chain, it is important to understand the performance from a real end user's perspective (QoE metrics measurement) and also understand the network, hardware, and CDN health (QoS metrics measurement).

### Methodology for Measuring End-User or QoE Metrics

While there are multiple ways to monitor the performance of systems, network, and infrastructure, there are two popular methods of monitoring performance from the end-user perspective:

- **Active monitoring or synthetic monitoring:** Uses automated tests that run at scheduled times to collect performance data. These tests simulate the behavior of a real user in a preconfigured environment. They run in a specified device type over a specific network type, and test probes can be deployed either as backbone nodes (i.e., test machines sitting in data centers all around the globe) or as last-mile nodes (i.e., test machines sitting behind a real home–like internet connection).
- **Passive monitoring or real user monitoring (RUM):** RUM reports real-time performance data as experienced by a real end user. The data is collected directly from real users using the service and captures the behavior of each one. RUM monitoring requires the service provider to implement a RUM SDK (or a client-side code) in either the player itself or the browser or app using the player.

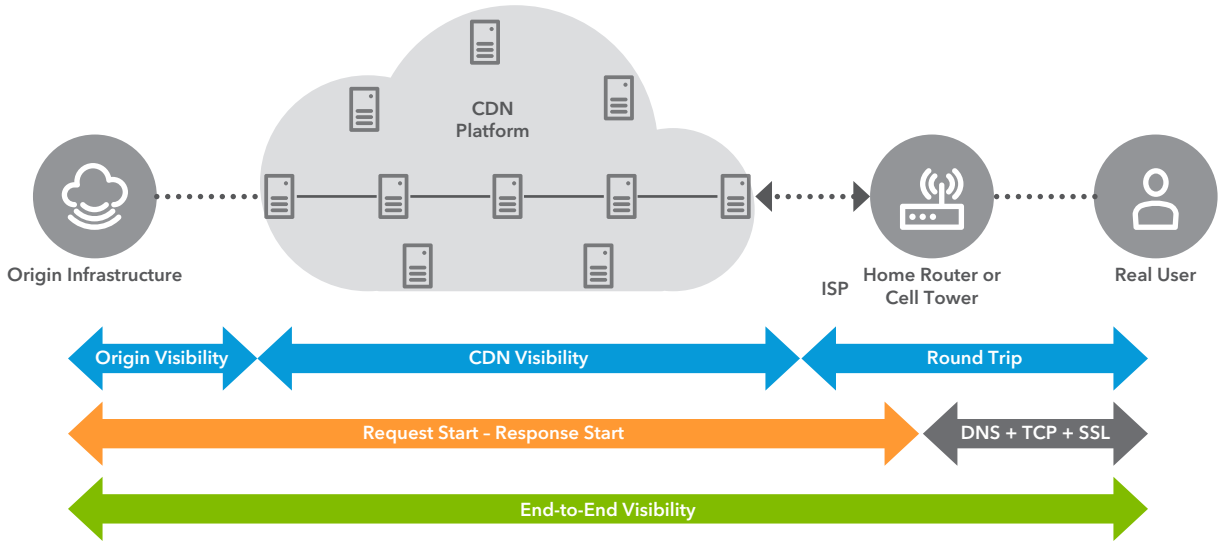
Appendix Table 4 provides use cases and benefits of synthetic and real user monitoring.

### Measuring CDN Edge Performance or CDN Quality of Performance (QoP)

CDNs today manage a significant portion of the world's video streaming traffic and are ubiquitous in mitigating the toughest challenges of delivering video content over the internet. According to the **IDC MarketScape: Worldwide Commercial CDN 2019 Vendor Assessment report**, which positioned Akamai in the "Leaders" category, CDNs will manage 72% of internet traffic by 2022, up from 56% in 2017.[5]

Along with end-to-end performance visibility, it is also imperative to methodically measure the performance of the purpose-built solutions across the video delivery value chain, which includes measuring the CDN's platform performance.

The diagram here illustrates a high-level workflow in a video streaming use case, identifying the key elements and associated performance visibility elements:




| COMPONENTS | DESCRIPTION | METHODOLOGY |
|---|---|---|
| Origin Visibility | Visibility into the round-trip data flow between the CDN edge server and the content preparation system's origin infrastructure | QoS metrics for origin performance monitoring defined in **Appendix Table 3** |
| CDN Visibility | Visibility into the CDN platform between the first byte request received by the CDN edge server from the client device and the response back by the CDN platform | Combination of edge and midgress QoS metrics defined in **Appendix Table 3** |
| Round-Trip Visibility | Visibility into the round trip between the client device and the CDN edge server (nearest to the end user) | **Multiple Factors:** Last-mile ISP performance, last-mile home router or cellular performance (in case of mobile devices), the client device itself |

Many RUM and synthetic testing tools help measure end-to-end performance, as well as individual component performance such as the DNS performance; however, it is generally difficult to use these tools to get granular component-level details, such as performance of the CDN network (QoS metrics).

This calls for specialized methods to be defined to measure the CDN performance using QoP metrics that provide visibility into a CDN's performance (CDN QoS) and, at the same time, also relate to the end user's viewing experience (QoE metrics).

### Defining the CDN Edge Performance or CDN Quality of Performance (QoP)

#### Who should define the methodology?

Every CDN has a different network-level architecture and implements different types of optimizations within their networks. It is your CDN's responsibility to provide clear and transparent performance measurement methods.

#### What should the methodology achieve?

Given that the methodology is meant to measure the video quality and performance, the target should be to define the specific CDN QoP metrics that measure performance for video traffic (manifests and segments).

Since the methodology is specific to the individual CDN, a definitive methodology should be adopted to make these metrics easily relevant and relatable to the QoE metrics commonly used by RUM and synthetic testing tools. Defining QoP metrics as discussed in the previous section would be a step toward that end.

#### How should the performance visibility be provided?

**Data Feeds:** Data feeds bring low-latency data feeds on video delivery performance, CDN health, latency, errors, and events through raw logs mainly targeted for operational visibility.

**Reports:** Reports bring visibility into CDN platform performance through customizable and low-latency reports and dashboards.

**Insights:** Insights show performance trends and how they relate to regions, content type, consumption, network conditions, performance benchmarks, and key performance indicators (KPIs) to measure a viewer's quality of experience.

**Best Practice:** Reinforce the need for CDN accountability to define video quality and performance methodology using QoS and QoP metrics delivered as raw feeds, reports, and insights for operational and business needs.

## Choosing the Right Tools for Effective Measurement

Once the metrics to measure video delivery performance have been established and the methodology to measure these metrics has been identified, the next important task is to identify or build the tools that will be used to quantitatively measure the video delivery performance.

### Quality of Experience (QoE) Measurement Tools

There are multiple RUM and synthetic measurement tools available for QoE measurement and monitoring, including tools from Conviva, Nice People At Work, Mux, Bitmovin, Touchstream, and Telestream.

Akamai also offers the **Media Analytics** solution for QoE measurement, which is made up of two key modules:

- Quality of Service (QoS) Monitor: Provides visibility into the quality of video playback and viewing experience to help gain audience engagement insights
- Audience Analytics: Provide a comprehensive overview of key trends around audience behavior as they engage with video content

**Note:** RUM and synthetic tools are ideal for understanding an end user's QoE; however, there can be multiple scenarios in which the insights from these tools might not provide a complete picture of video quality improvement or degradation and might make it difficult to pinpoint what is responsible for the issue.

It is helpful to have a checklist of questions to evaluate these metrics and insights:

- **How have the QoE clients been implemented in the player?**

  Incorrect test object implementations can cause erroneous performance representation.

- **What methodology is being used?**

  There is a clear distinction between QoE and QoS and the associated methodologies.

- **Why was the specific time frame selected?**

  It is most effective to evaluate multiple scenarios across a length of time. Metrics from a specific time frame with nonoptimal performance might be a misrepresentation.

- **Are the stats for a specific region and network, or for a CDN and percentile of users?**

  A nonrepresentative sample can show an unrealistic state of affairs.

- **Which tool is used to compare the data?**

  Different tools can result in different statistics for the same metric and can result in incorrect inferences.

### Quality of Service (QoS) Measurement Tools

QoS measurement tools measure the performance of specific components of the video delivery value chain, including origin infrastructure and CDN video delivery performance.

In order to help organizations measure CDN performance and CDN QoS, Akamai offers **Media Reports** to monitor video streaming quality to ensure it reaches the end user with the highest quality for a superior user experience.

Providing media customers with visibility into platform performance helps organizations make timely decisions. This is a **key area of focus** for Akamai. Initiatives and enhancements are in progress to provide platform performance visibility using QoP metrics; provide low-latency, raw log data for operational monitoring; provide greater visibility into platform capacity; and troubleshooting of individual end-user requests.

**Best Practice:** Use a real user monitoring (RUM) or synthetic measurement tool to understand the viewer's quality of experience. It is also helpful to use the list of questions on the previous page to evaluate metrics and insights. Use service-quality tools that incorporate quality of performance (QoP) metrics to provide visibility into CDN performance.

## Summary

Amid the growth of OTT consumption in recent years, viewer expectations around video quality and viewing experience has matured. What started off as a "good to have" requirement has now become a "mission critical" necessity.

Understanding video quality and how to measure it is the starting point. The next step is to implement a framework to measure video quality and performance, not just from the viewer's perception, but also the quality of service being delivered by the components in the video delivery value chain. These steps will better engage the viewers and help organizations monetize the engagement from advertisers and subscribers to deliver a successful business impact.

# Appendix

### Table 1: QoE Metrics for End-User Viewing Experience Measurement

| QoE METRIC | DESCRIPTION | IMPACT IF POOR |
|---|---|---|
| Availability | Content availability at the time a request is sent by the end user | Inability to stream or interruptions watching streams |
| Bitrate | Video quality indicated by the number of bits transmitted over a set length of time | Lower-quality streams often translated to grainy and lower-resolution video |
| Playback Error | How many playbacks were abandoned because of a playback error after the initial rebuffering was completed | Premature end of the video or the player/browser crashing |
| Rebuffering | A stall in video delivery caused by video segments downloading slower than play rate | Stuttering in video / frozen video and audio, and possibly the "wheel of death" on the screen |
| Startup Time | The time from when playback is requested until the video starts playing | Long wait time for the video to start, or long switching time between live or linear channels |
| Video Start Failure | How often playback attempts are terminated during video startup before the first video frame is shown | No video shown at all |

### Table 2: Rebuffering Metrics and Definitions

| METRIC | REPRESENTATION | QoS DEFINITION |
|---|---|---|
| Rebuffering Percentage | Percentage | Amount of time video spent rebuffering as a percentage of the total time video was requested |
| Rebuffering Frequency | Number | How often the video rebuffered per minute of video playback that the viewer attempted to watch |
| Rebuffering Duration | Median or Percentile | How long the viewer has to wait for their video to reload as a percentage of video watch time lost to rebuffering |
| Rebuffering Count | Median or Percentile | The number of rebuffering instances aggregated across the viewing duration |

### Table 3: QoS Metrics for CDN Performance Measurement

| QoS METRICS | DEFINITION | VARIABLES |
|---|---|---|
| Traffic/Hits | Total volume of data getting delivered across the CDN platform, in terms of hits and bytes | Origin, midgress, and edge hits and bytes |
| Throughput | Bandwidth available to deliver content across the CDN platform | Throughput in Mbps |
| Offload | Total volume of requests that did not go back to the origin, in terms of hits and bytes | Offload hits and offload volume |
| Availability | Hits that resulted in successful responses, compared with the total number of hits | Edge and origin responses |

### Table 4: Synthetic and Real User Monitoring

| ACTIVE OR SYNTHETIC MONITORING | PASSIVE OR REAL USER MONITORING |
|---|---|
| **Using synthetic monitoring, one can:**<br>• Simulate a controlled test environment with preconfigured variables<br>• Schedule tests to run when needed<br>• Determine what needs to be tested and build tests based on the monitoring requirement | **Using passive monitoring or RUM, one can:**<br>• Vary test environments with every user to aggregate real user data<br>• Collect data for every user accessing the application<br>• Configure variables to track and collect data in real time |
| **Active or synthetic monitoring helps to:**<br>• Reduce resolution time by actively tracking potential issues before they impact end users<br>• Set alerts for when any metric value falls below or rises above set threshold<br>• Monitor proactively in a pre-production environment | **Passive monitoring or RUM helps to:**<br>• Capture performance of real users from different devices, browsers, geolocation, etc.<br>• Correlate user engagement with service performance<br>• Get historical data to predict performance trends, business outcomes |

## SOURCES


1) eMarketer Global Digital Video Report 2019
2) Nielsen Total Audience Report, February 2020
3) https://content.akamai.com/gl-en-pg9246-sensum-whitepaper.html
4) https://en.wikipedia.org/wiki/Quality_of_service
5) IDC MarketScape: Worldwide Commercial CDN 2019 Vendor Assessment

Akamai secures and delivers digital experiences for the world's largest companies. Akamai's intelligent edge platform surrounds everything, from the enterprise to the cloud, so customers and their businesses can be fast, smart, and secure. Top brands globally rely on Akamai to help them realize competitive advantage through agile solutions that extend the power of their multi-cloud architectures. Akamai keeps decisions, apps, and experiences closer to users than anyone – and attacks and threats far away. Akamai's portfolio of edge security, web and mobile performance, enterprise access, and video delivery solutions is supported by unmatched customer service, analytics, and 24/7/365 monitoring. To learn why the world's top brands trust Akamai, visit akamai.com, blogs.akamai.com, or @Akamai on Twitter. You can find our global contact information at akamai.com/locations. Published 05/20.