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The Big Guide To OTT:

Part 5 - Assuring Viewer QoE

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Contents

Series Overview

By Paul Martin. The Broadcast Bridge.

The Big Guide To OTT provides deep insights into the technology that is enabling a new media industry.

As OTT delivery grows, driven by both consumer demand and content provider strategy, there are many adjustments to manage. They include new production approaches, scaling content distribution, personalizing, protecting, and monetising content, and assuring audience QoE.

Content providers are delivering a mix of live, linear, and on-demand content. Business models are blending - subscription with advertising and direct-to-consumer with service aggregation. The internet-enabled OTT delivery model is driving the media industry through a giant transformation.

There are many broadcast disciplines to leverage in OTT – the concept of "broadcast-grade streaming" means streaming should match broadcast's capacity for highly consistent, highly scalable delivery of high-resolution content at low latency. There are also new disciplines for content providers to embrace, like delivering highly personalized content and building new relationships with consumers and ISPs.

The OTT technology domain builds on core broadcast distribution disciplines and adapts them to internet-based delivery. New contribution methods, ultra-low latency encoding, and high speed broadband streaming, could mean that 'streaming-grade' will become a new gold standard for content delivery. But the fixed and mobile broadband networks we rely on, and the myriad of devices we use,

mean that we need to work differently to manage content accessibility and quality. So while the content may be largely the same, there are significant differences to manage between the worlds of OTT and OTA.

The Big Guide To OTT is a multi-part series. Each part tackles a different theme and there are three or more articles per part.

Available now:

Back To The Beginning

Content Origination

CX - Customer Experience

Managing Latency

Assuring Viewer QoE

New Parts coming soon:

Broadcast Grade Streaming

Streaming Sustainability

Quality Of Experience

Monetization & ROI

Internet Infrastructure

Content Delivery Networks

Assuring QoE From The Network Side

By Paul Martin. The Broadcast Bridge.

The features we love about OTT services – such as combined linear and on-demand content, multi-device viewing mobility, tailored viewing experiences, and in some cases better resolutions – are driving the general rapid uptake of OTT services.

Figure 1 – A simplified network map for OTT streaming delivery.

But these features rely on dynamic and complex IP-based video delivery platforms, which in turn makes quality assurance extremely challenging. What does quality assurance look like for OTT services, and how are network-side monitoring solutions supporting the continued drive towards excellent QoE (Quality of Experience)?

Network-Side

Before discussing quality, it is necessary to clarify the scope of "network-side".

Network-side is inherently focused on service-level measurements and the impacts and actions that span multiple streams to multiple end customers simultaneously. This contrasts with client-side that is inherently focused on an individual customer experience (albeit data can be aggregated for an entire audience).

One of the primary challenges with OTT quality assurance is that different consumers can have very different service experiences for a wide range of reasons. The dynamic nature of networks and internet-based delivery is a general risk to streaming video quality. To manage quality, it is therefore imperative to

understand network paths between origination points and the receiving devices (see Figure 1). And to proactively protect QoE, it is necessary to focus on network-side measures and network-side corrective actions.

But don't think that "network side" means it is impossible to understand individual customer experience. On the contrary, from the network side it is possible – and very necessary – to understand quality of service (QoS) to all as well as quality of experience (QoE) to individuals (see below).

Because of the complex OTT delivery network reality (see Figure 1), OTT service providers have a tough job to deliver excellent customer service. Not only should they be able to monitor QoS and QoE, but they should also be able to pinpoint incidents, understand root cause, and assure quality, all in real-time. OTT service providers who are most sensitive to customer dissatisfaction from poor service should also be able to predict potential future incidents and avert them.

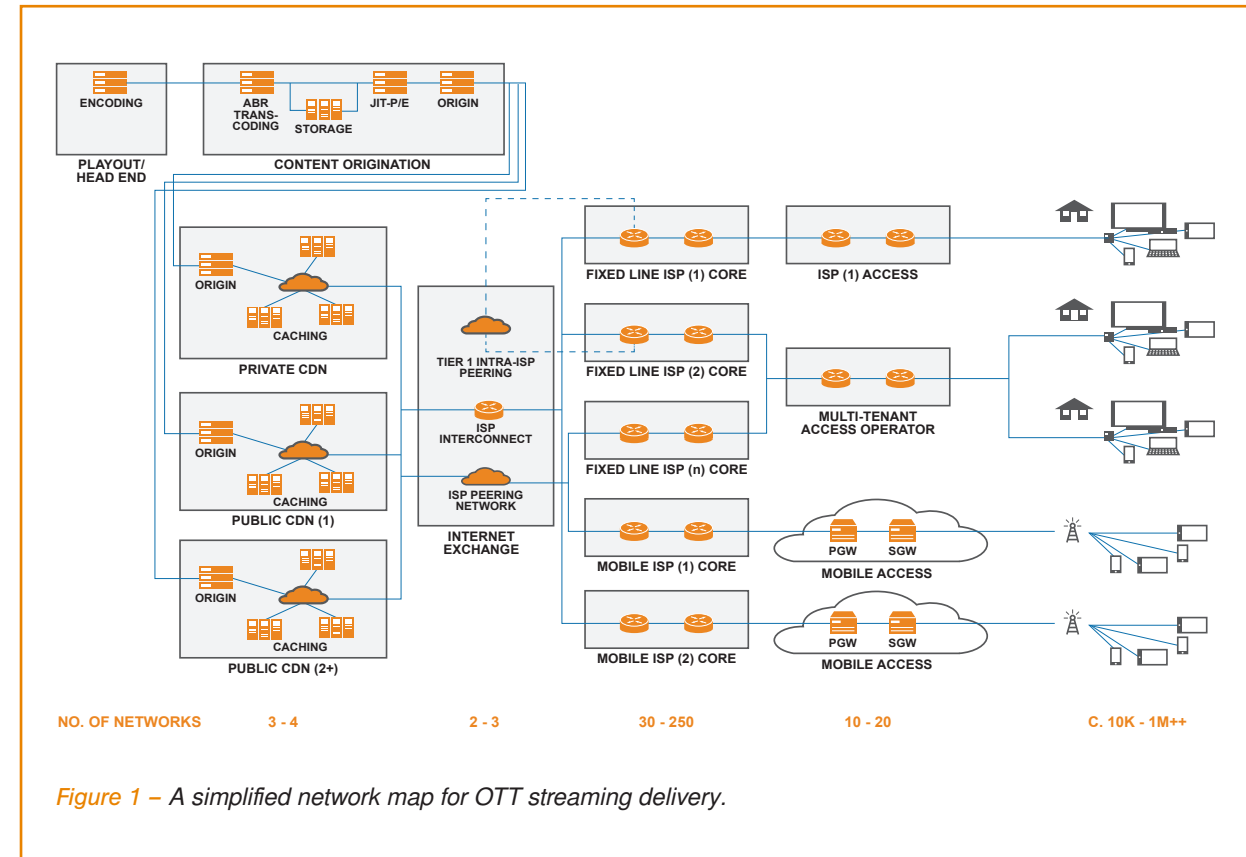The good news is that lessons have been learned about how to approach this

problem by IPTV and Cable TV operators. Like OTT service providers deploying Apps or websites, these operators deploy set-top-boxes. Over many years, it's become clear that set-top-boxes can only tell you something has gone wrong. They cannot tell you exactly where the problem is in the delivery chain. Measuring at the OTT App is the equivalent of the set-top-box. But OTT is more complex in this regard because to know what went wrong requires monitoring and corrective action over multiple third-party network domains.

OTT service providers deploy client-side monitoring for good reason – to know the activities and experiences of their customers. The capabilities of client-side monitoring cannot be fully replaced by

network-side monitoring. But network-side capabilities must take the lead in assuring quality of service and quality of experience at the consumer's device. OTT service providers need to be able to see inside the delivery network and directly supervise QoS and QoE.

Quality In OTT

Quality for this article is grouped into three distinct categories – quality of content, quality of delivery and quality of experience. Each can individually affect a consumer's decision to continue watching an OTT service provider's content.

Quality of content – including topics like image resolution, subtitles, audio loudness and more – is normally measured at the point of ingest to the

delivery platform. In OTT, this typically means the file or live encoders. Today, as important VOD content is stored in various caching servers, and OTT service providers grapple with QoE subjects like stream start-up time, there is growing pressure for quality control on the content that is stored inside CDNs.

Quality of delivery is concerned with the actual delivery of content in the required bitrates, package-types and language versions into the locations where the OTT service is provided. This can be measured at an individual stream level or at an aggregate audience level. Of growing importance is the ability to predict and avoid quality-affecting situations, such as network congestion, whether they are under the OTT service provider's direct control or not. Quality of delivery is important for both live streaming services and VOD services.

Quality of experience is the ultimate measure, reporting how individual consumers are experiencing the video playout. Measures here include bitrates played, bit-rate consistency/changes, rebuffering rates, and start-up times. Individual consumers can have a very different experience of the same OTT service for a wide range of reasons – device performance, LAN performance and network contention are some examples. The OTT service provider needs to manage this situation above all else to assure the end customer's satisfaction.

QoS And QoE Measures

Network-wide measures are often referred to as QoS measures, simply because the network-side can see performance of the whole service – i.e., every stream that passes through the network. This compares with client-side measures

which can be grouped under the heading of QoE, because QoE is an individual experience measure. But this loose categorization hides the fact that QoE is very measurable from the network-side.

While there are good examples of network-side and client-side integrations in the industry, they are few. Today, the most typical situation for OTT service providers to manage quality is to monitor stream quality at the delivery platform (i.e., the encoder or the origin) and to use client-side monitoring for understanding QoE and to balance traffic between CDNs. But as the cable and IPTV operators learned, to fix or prevent an incident you need to know exactly where the root cause is. Normally, in the multi-dimensional pull/push/cache system of OTT, the root cause is somewhere inside the complex set of network interconnections between the encoder and the device.

"In today's ABR streaming world, monitoring vendors must focus on both enhancing solutions for multi-supplier OTT delivery and supporting the transition to new hybrid on-prem and cloud architectures", states Joel Daly, VP Product Management at Telestream. "And with service deployment agility evolving rapidly through advances in automation and orchestration solutions, real-time data from monitoring solution is a critical feedback mechanism for delivering both live and on-demand OTT services."

On the network-side, it is essential to measure performance of the network in a customer-centric manner. In other words, to measure the network using QoE metrics. It is already proven from integrations between network-side and client-side tools that it is possible to measure QoE from the network. It is also clear that this provides an early-warning

tool for managing service quality. By interpreting network-side data correctly, OTT services can avert customer experience incidents. A classic example relates to the sustained bit-rate metric (Figure 2), which can be detected early by network-side tools.
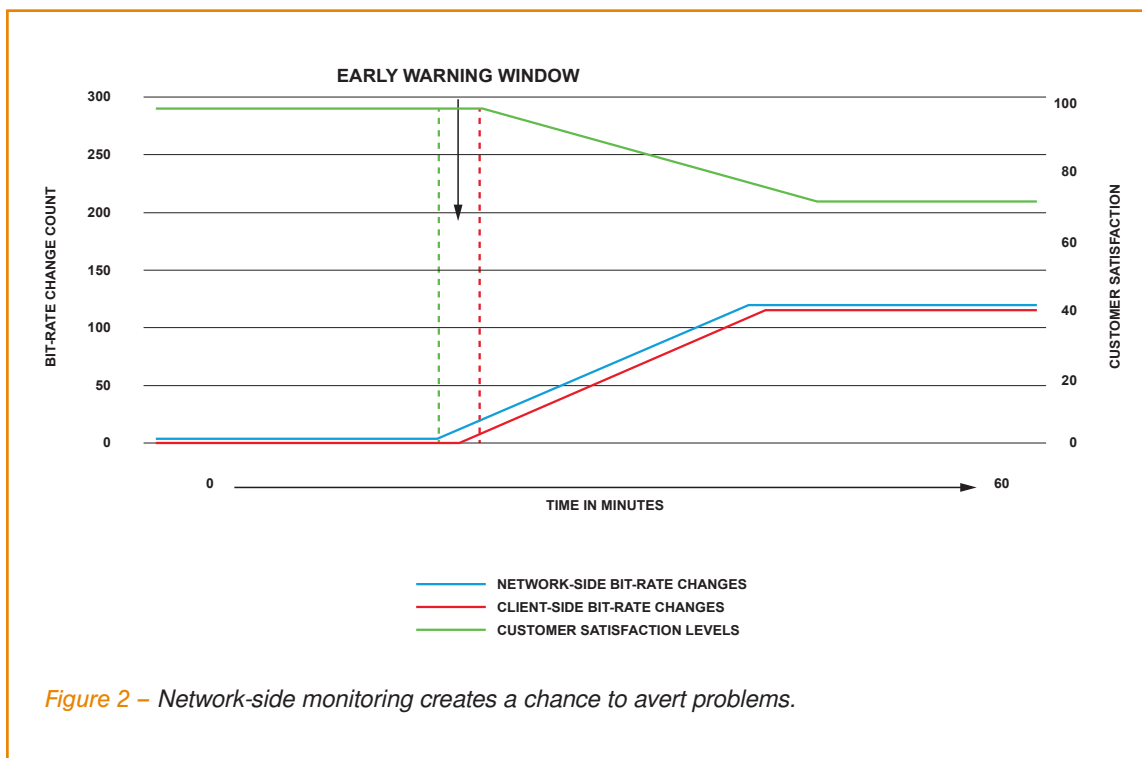

Figure 2 – Network-side monitoring creates a chance to avert problems.

Monitoring From The Network Side

By Paul Martin. The Broadcast Bridge.

At its core, the network-side can be an early warning system for QoS, which in turn correlates to actual QoE performance.

This article considers the two types of network monitoring available to us, relative priorities for the points of measurement, and how the video platforms contributing to OTT services are evolving to support OTT quality at scale.

The Measurement Method

Network-side measurement of content, delivery and QoE performance is either through service monitoring which focuses on an individual or small subset of the audience, or platform monitoring which focuses on all inputs and outputs from a particular technical component such as a CDN or encoder.

Service monitoring uses active testing, where probes simulate OTT clients. This is typically the most widely used measurement method, because it is most cost-effective for smaller, targeted sample testing and is generally able to identify most quality issues. Service monitoring can determine whether, for example, all ABR profiles can be streamed successfully to a particular device type, or if the latest VOD content can be streamed from each CDN, or if the queued-up ads are ready to be played during the break. Because active testing draws content to a client device, a side-benefit of the tests is that caches can be pre-warmed with the tested content, which is particularly helpful if multiple caches in the CDN can all be populated with the necessary content from the test activity.

Service monitoring can be targeted or broad. It can focus on single live streams for the duration of an event, or it can focus on an entire VOD library. It can simulate 20 end customers, or 20,000. The deployment depends on the budget and value of the content, but the flexibility exists to cater to a wide range of requirements with today's cloud-based SaaS solutions. Monitoring processes can be expanded or contracted according to the content and audience locations and paid for accordingly. Data analytics, required in real-time to be of most use to the OTT operator, can be accelerated by elastic computing.

Service monitoring for live events generally involves monitoring of all stream variants continuously, as any Playout MCR demonstrates. But in OTT it is not enough to monitor the streaming output of the live encoder or the origin to confirm all required bitrates and packages are streaming as expected. The output to the client devices is where the quality issues manifest once the streams have passed through the various network paths. So, in the absence of direct network control, or real-time stream-level reporting from CDN suppliers and the ISPs, or sufficiently scalable external monitoring tools, OTT service providers naturally relied upon what they could control – client-side monitoring. But this leads to the conclusion, as mentioned before, that troubleshooting root cause or proactively assuring quality is not possible.

"In today's dynamic media landscape, where viewers have high expectations, monitoring video streams has become indispensable," states Anupama Anantharaman, VP Product Management at Interra. "New trends and advancements, such as the shift towards all-IP infrastructure including the ST 2110 standards, FAST channels, etc. have further emphasized the need for comprehensive video monitoring. By implementing end-to-end monitoring solutions, broadcasters and OTT operators can closely monitor the entire content delivery chain for audio-video quality, closed captions, and Ad insertions from encoding and transcoding to CDN distribution and playback.

Automation is playing a pivotal role in making video monitoring and root-cause analysis more efficient. E.g., Automated video quality tracing and the detection of anomalies or deviations in key performance indicators (KPIs) can effectively prompt alerts or notifications, initiating further investigation to ensure a timely response to potential issues before they adversely affect the viewer's quality of experience (QoE). Furthermore, the utilization of automation facilitates uninterrupted monitoring, enabling broadcasters and operators to oversee their services round-the-clock, devoid of manual intervention."

Like most troubleshooting activities, a lack of root cause diagnosis reaches a point where it becomes necessary to see 100% of the platform for extended periods of time to know what is truly happening. Platform monitoring, fulfilled through passive monitoring by tools

external to the video delivery platforms, can meet this need.

This external platform monitoring method is intensive and relies on collaboration with the platform owners to insert line taps to see what is "on the wire". This can also become expensive, but sometimes it is the only way to resolve a persistent issue.

External platform monitoring is made more complex by the distributed nature of OTT delivery networks. A single CDN could have tens or hundreds of edge cache servers all contributing to the delivery of streams. Or there could be 20 different ISPs contributing to the final delivery over their networks. There are multiple multi-tenant platforms working
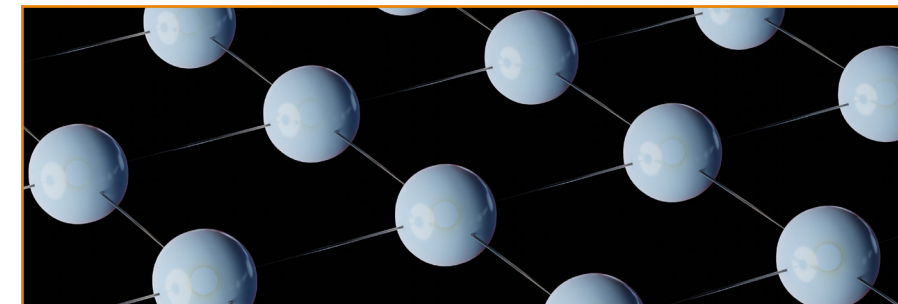
together to deliver OTT video – CDN, IXP, ISP, Access Network, and home routers. Often, external platform monitoring has to be focused in on the most critical network junctions, like an Origin interfacing to multiple CDNs.

Internal platform monitoring is provided by the platforms themselves, like a CDN or an ISP. Because these platforms are often multi-tenant and based on total compute / storage / network performance, the internal monitoring activity is generally focused on availability – i.e., if the infrastructure is operating

within tolerances, then it is healthy. But this can hide a plethora of issues with video quality and QoE.

One of the main quality challenges is to consistently sustain a stream's bitrate. Bitrates can fluctuate due to congestion in the CDN, congestion in the ISP networks and peering networks, the impact of many devices simultaneously requesting the same content from the Origin, the nature of the access network technology (e.g., ADSL vs. FTTP), and

high-performance streaming to paying customers ABR is not the final solution. There is a need to solve this issue as far as possible, given the myriad of potential hurdles a stream can face on its way to a device. This QoE issue can be understood in detail by network-side measurement tools.

CDNs, which represent the last video-specialised environment in the delivery chain before the consumer device, are evolving to give this stream-level

consumer will be happy. As the final point of delivery into the last-mile network, this works much the same way as the head-end for over-the-air broadcasting.

Considering the order of priority for service assurance monitoring today, the below diagram indicates priority 1 for active testing of encoder output (including file transcoders for VOD assets), origin output (which can be multiple points of output) and CDN egress. Already this raises the bar on what most OTT service providers see because CDN egress is not often available in the appropriate granularity. Note however, that content quality monitoring specifically, if done post-encryption, requires de-encryption to visualize the asset. While eminently achievable, and most often needed in workflows with combined transcoder-packager functions that cannot be monitored post-transcoder, this requires an extra level of integration with the DRM supplier as opposed to the delivery and QoE quality monitoring which can be done simply on the packaged and encrypted streams.

Priority 2 is the egress from the edge of each access network, which is a bigger task and currently requires sample-based service monitoring or a deep relationship with an ISP. Priority 2 also includes continuous passive monitoring of the Origin egress, which is often required when active testing of origin and/or CDN egress does not lead to a clear diagnosis. Congestion, request time-out, and load balancing configuration issues on the Origin are more complex problems to understand and often require passive monitoring.

Evasive Action
Measuring is one thing. Performing real-time analysis to create actionable insight is another. Typically, monitoring is against

agreed tolerances such as a minimum average bitrate across all streams from a single CDN. Thresholds are pre-defined based on the known consumer ecosystem served by the OTT service provider. Alarm thresholds are normally set to be as proactive as possible, to report signs of degradation that need to be addressed, rather than waiting reactively for outages.

Raising an alarm against a threshold is straightforward. Correlating network-side service degradation with customer dissatisfaction is more complex. But this is the standard that must be achieved for OTT service providers to assure quality. Advanced solutions today can correlate leading (as opposed to trailing) performance indicators in real-time across various network domains, including data supplied by the client-side monitoring domains. The evasive action often relies on network re-routing to avoid the problematic routes for the future streams, which today means that client-side monitoring tools re-direct streams to another CDN. But is there a better way?

"Highly evolved OTT operators are often frustrated by a lack of visibility into their CDN services," states Sergio Carulli, Chief Innovation Officer at MainStreaming. "CDNs should be transparent in order to support OTT operators' quality assurance efforts. By adding CDN data to holistic service monitoring tools, the OTT operator can have a deeper understanding of the reasons for each customer's experience. And if CDNs incorporate data from downstream network domains into their own stream management algorithms, they can make better decisions about how to manage the end customer's QoE."
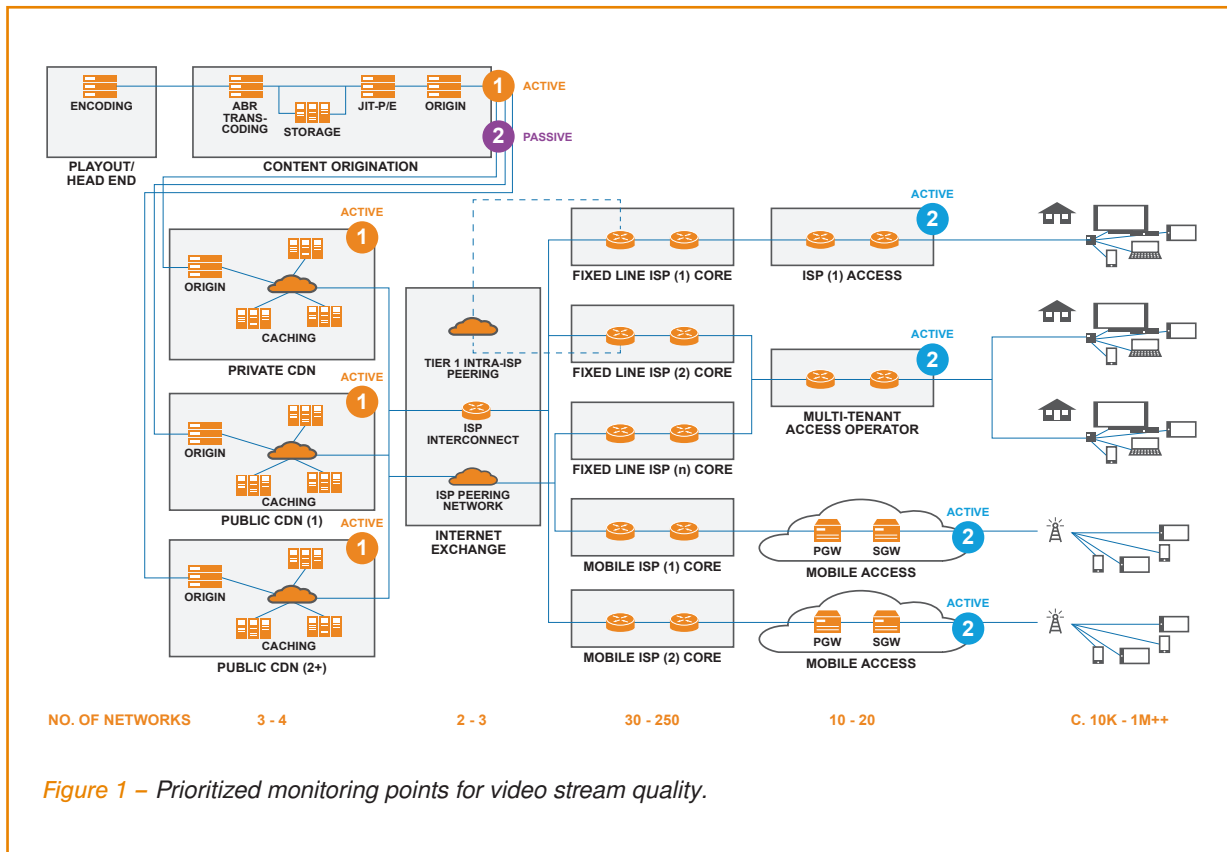

Figure 1 – Prioritized monitoring points for video stream quality.

more. ABR was invented to deal with the fact that sustaining a bitrate over the internet is a difficult task. But stepping up and down the bitrate ladder is not an ideal customer experience, and for

QoE data to their OTT service provider customers. As a rule of thumb, if the quality of the stream meets QoE specifications at the egress point from CDN Edge Cache it is most likely that the

The Future Of Network-side QoE Monitoring

Quality assurance is a never-ending task. New content formats, dynamic networks, changing devices and evolving customer expectations mean that OTT service providers need quality assurance to be a core competence.

OTT service providers need to have holistic service monitoring tools to understand the overall service they are providing to their audience. The good news now is that SaaS solutions and cloud deployments make this cost effective and easily deployable. Live streams, VOD streams and VOD assets can all be routinely sampled with measurement rules defined ever more precisely over time. OTT service providers can really know their stream health and customer QoE.

The partnership between the OTT service provider and their monitoring systems, plus their CDN and ISP platform partners, will provide the ability to understand QoE from a network perspective. Today, CDNs are the primary video-centric platform partner to rely on, as they look upstream to the Origin and downstream to the ISPs. Their final touch and view of the video before it is received by the consumer, and their ability to act and proactively move a stream to a new network path is fundamental to excellent QoE. Already, CDNs work with ISPs but this relationship will evolve to become much closer and more proactive, particularly for the largest streamers delivering to the largest audiences.

We are on a path towards OTT at scale with many millions of concurrent streams from single OTT operators to their audience. Some OTT services already reach this size on a regular basis, but in the coming years many more OTT

services will. Quality control is already a very real issue for many OTT operators, and it will only become more important.
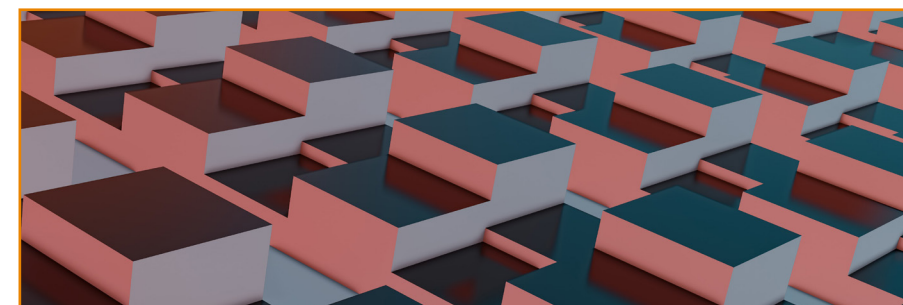
Understanding The Client-Side OTT Customer Experience

By Paul Martin. *The Broadcast Bridge.*

The criticality of service assurance in OTT services is evolving quickly as audiences grow and large broadcasters double-down on their streaming strategies.

Gone are the days where good enough is good enough. Audiences are quick to criticise when there are basic issues with a service, especially when they are watching exclusive live content. Client-side monitoring and analytics has been a staple of the D2C streamer technology stack for many years. It continues to evolve to measure and report the holistic customer experience in real-time, which now includes combining forces with network-side monitoring in order to detect the actual source of quality issues.

What Is The OTT Customer Experience?

Let's start with the premise that

OTT Customer Experience = Content + User Experience (UX) + Quality of Experience (QoE)

We can (and must) debate the relative importance of each, but let's just say that all three elements are sufficiently important to really matter to the success of the OTT operator's business.

In this article we're looking at the technical aspects of OTT, so while we may easily accept in some instances that content is king, we will focus here on UX and QoE. These domains are becoming

the primary battleground for customer satisfaction as OTT services become the exclusive home of high-profile content like live sports, and as competition heats up between OTT service providers.

Quality Of Experience And User Experience

QoS (Quality of Service) and QoE (Quality of Experience) have been standard terms for many years. QoS is focused on technical performance of the video stream from the engineering perspective – are all the video bitrates available to the consumer, how much are the video bitrates moving up and down their ABR ladder during a session, what is the video latency, etc.? QoE looks at the same things from the customer's perspective – e.g. how fast does the video start-up, did the video fail to start, how often does the stream rebuffer, how many customers are actually receiving the top bit-rate, etc.?

For a D2C service, the customer's perspective (i.e. QoE) is of paramount importance. OTT QoE should be compared with QoE from the pre-existing satellite and IPTV/Cable TV services, and then OTT service providers should act accordingly on the delivery infrastructure to fine-tune performance. QoS remains important at the engineering level and should be used to establish overall
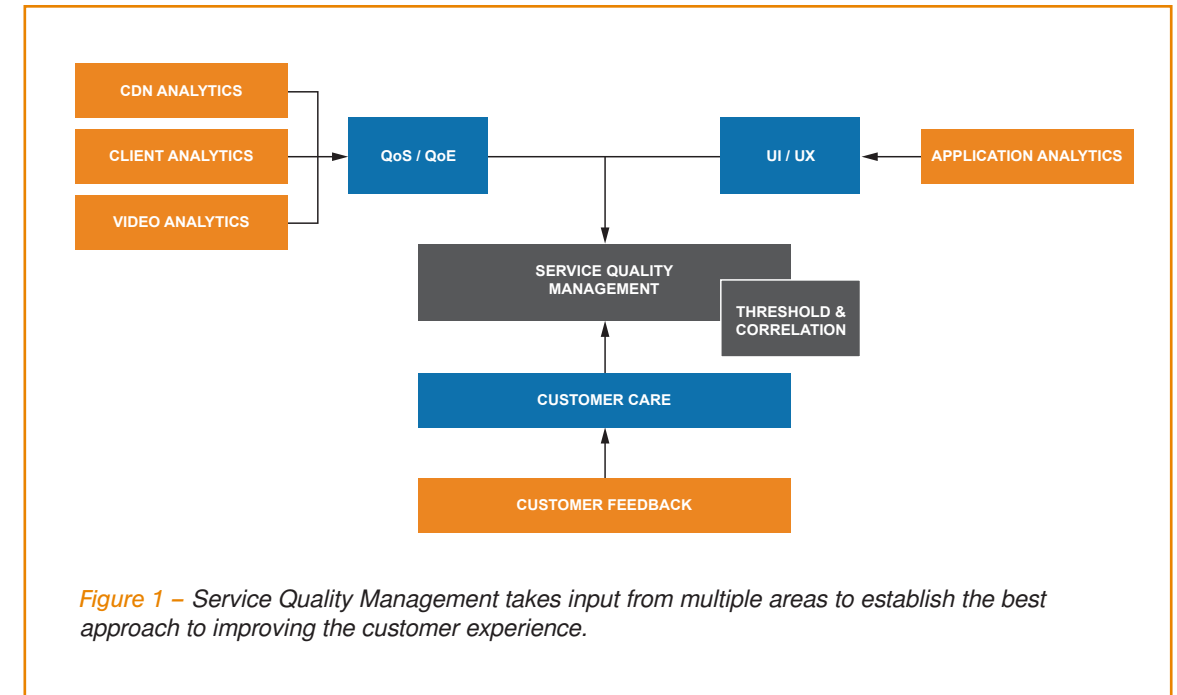

Figure 1 – Service Quality Management takes input from multiple areas to establish the best approach to improving the customer experience.

technical health of the platform and its ability to deliver what the customer expects. But QoS alone can hide the realities of the customer experience, for example by focusing on the average bitrate or the availability of a stream when in fact an individual customer might experience lower-than-requested bitrates or even video outages like black screens on a valid stream during the most important part of the program. Moving from aggregate QoS metrics to individual QoE metrics is an essential part of succeeding in OTT.

Just as QoE trumps QoS, UX (User Experience) can trump QoE. UX reflects the experience of the user with the usability of the service, which is measured by Application analytics. Measures such as time-on-site, number of clicks, app performance, content placement and consumption method provide a perspective on ease of use and ease of finding the desired content. These

measures can then have appropriate targets set based on focus group research and best practice expectations, with fine-tuning implemented accordingly.

Leading OTT service providers focus on a range of actions to satisfy their customers. They adapt their apps to extend video performance and customer consumption. They identify the best performing routes and navigation through their services to match their technical quality goals. And they evolve and migrate their apps to keep up with new technologies and innovations.

But whether QoE is more important than UX or vice versa, the key point is to measure both and correlate them with each other to detect cause and effect patterns, which can be used to proactively make system-level changes during streaming events to improve the customer experience. This machine-captured data, measured from a

technical and customer perspective, can be combined with actual customer feedback and re-correlated to establish the most intelligent approach to service improvements. This Service Quality competency should exist at the core of the D2C streamer.

Applying The Necessary Tools

D2C streaming produces a lot of data. It is inherent in the fact that individual streams are being delivered to individual people on a specific device type, so every customer experience is unique. D2C streamers need to therefore understand what is happening. It is very different from the traditional broadcasting world.

Data-driven decision-making is therefore possible, and necessary. As any D2C business knows, you need to be able to trust your data and use it to make decisions about what to change in your service delivery. Once you are considering a change that will impact thousands or millions of consumers, the risks of getting it wrong are too high, and decision-by-opinion is too risky. For OTT video this type of change decision could include a permanent change to a CDN, real-time load-balancing between CDNs, offering a higher bitrate stream as a standard feature, or restricting bitrates during peak-time viewing.

Data comes from multiple sources – the client, the player, the ISP (multiple), the CDN (multiple), the head-end (on-prem / multi-cloud variants). To trust the data there needs to first be an independent and objective view – a single point of truth - of the performance of the content delivery ecosystem, which client-side monitoring tools can provide for the whole customer base. Second, the data source itself must be trusted and understood. This is where client-side monitoring solutions earn their keep. Validating the accuracy of the data from all elements of the streaming ecosystem is a continuous task. In addition, D2C streamers must work closely with all their technology partners to ensure the data is clean and correctly interpreted. For example, different CDNs will report different data sets or use different algorithms to calculate performance. As OTT services mature, these sorts of discrepancies cannot persist or else the concept of "data-driven decisions" becomes a false reality.

Searching For The Truth

Leading client-side monitoring and analytics solutions are pushing the boundaries of data source integration to reach the ultimate truth. By integrating network-side video monitoring solutions that understand video QoS and QoE the client-side solutions can quickly correlate video delivery data with customer application data and present information back to the OTT service provider.

Instead of just knowing that a group of customers are experiencing a drop in video bitrate, but not knowing why, these integrations can explain why. But a word

of caution – get the data interpretation right before jumping to conclusions! Assuming one CDN will perform better than another might miss the fact that the ISP's network is the issue, not the CDN's servers. It certainly would be worth trying a CDN switch if that is the best available information, but really the decision-making data should include ISP performance. CDNs that are focused on broadcast-grade streaming performance, and network-side Monitoring solution providers are working hard to gather ISP-level data to complete the picture and present it up into a single point of truth.

On the client itself, the data gathered in real-time must not impact QoE or UX. Software algorithms collecting data must not impact player or device performance. So minimal load and lean code is a must. External processing of data is also a must. Latest implementations focus only on listening to the events on the device, with data and decision-making transferred to highly scalable back-end systems (often cloud-hosted) for analysis, reporting and CDN selection decisions.

Changing Behaviours

D2C streaming involves a set of dynamics that are different from traditional broadcasting. Although it is true that some people may point out that the broadcasting industry has been following these approaches for years, just working with different technologies along the way.

First, D2C means being customer centric and taking the customer perspective about service experience. Although this is easy to say it can be complex to do in practice. Paying customers in particular need to be understood from a UX and QoE perspective, considering the impact of a poor experience could be more costly to the OTT service provider.

Second, D2C requires end-to-end views, which means having insight into all the elements of the distribution technology. In practice that involves a combined view of the network infrastructure and the end customer's experience on the device. Neither client-side nor network-side on their own can have a complete picture of the customer experience nor can either side suggest appropriate corrective action in isolation.

Third, D2C requires a data-driven approach. We are now equipped to know an individual customer's experience in detail, and service outages can be identified and the impact on each individual customer can be understood. The challenge is to have a solution that is scalable and does not slow down through any form of overloading, so we should look to elastic solutions rather than solutions limited by hardware capacity.

Fourth, D2C requires a proactive and real-time approach. Once customers are impacted the damage is done, and in a worst-case scenario the OTT operator's business is disrupted by a flood of complaints, enquiries and cancellations. In the technology stack, the CDNs are touching the video streams as they approach the consumer, and clients are processing the video stream and the UI. It is important to build very close relationships between each technology domain so that intelligent proactivity is designed into the software algorithms, and so that automated, real-time actions can be taken in response to the performance measures.

Fifth, D2C requires agility. Circumstances evolve quickly in the consumer world, and slow approaches are not good enough. So, recommendations from industry technology leaders are to move to DevOps instead of Waterfall

development approaches; use customer experience testing to validate multi-generational device versions and then provide feedback to vendors and perform continuous integration testing; get faster access to data in intuitive ways with voice recognition tools within the analytics process; and avoid slow ticketing systems between suppliers and move to a shared single-point-of-truth perspective between parties in the chain.
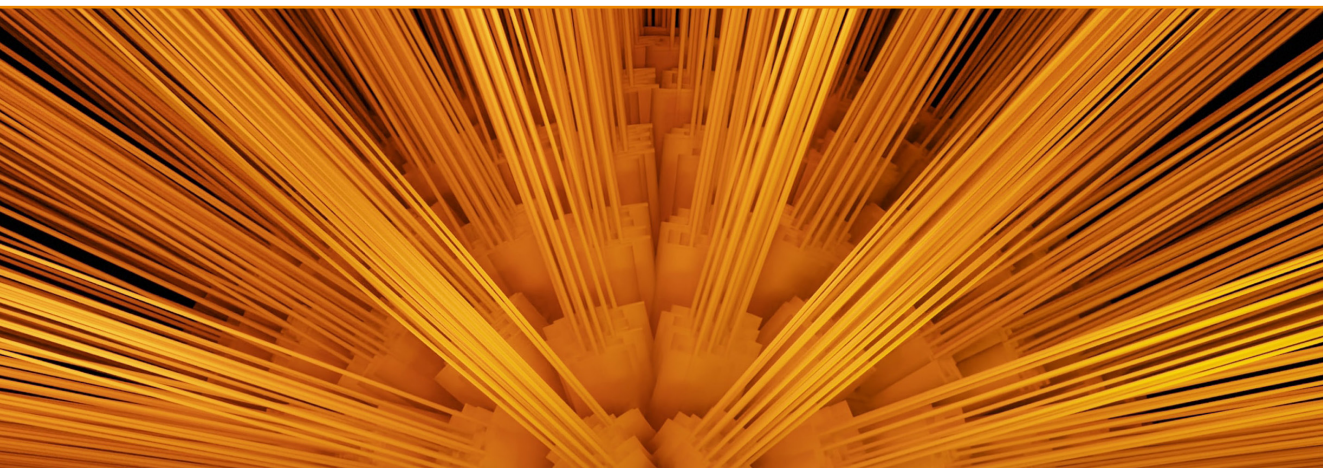
The Customer Is King

While content is always the creative battleground, UX and QoE are becoming equally important, and the customer is the ultimate judge.

Content and UX are very much in the hands of the OTT service provider. But QoE is generally outside of their direct control. They rely on a complex multi-tenant network and server architecture that is often being used by many other parties for many different uses. The trends towards DVB, multi-CDN and multi-cloud add more complexity. And while this is happening it has never been more important for OTT service providers to proactively assure QoE for their increasingly demanding customers.

QoE and UX need to be seen together. They are intrinsically linked, and they are both highly technical subjects that need intensive data analysis. The monitoring and analytics tools should combine and correlate the views from both worlds.

In the end, customer care is the single most important feedback loop for the D2C streamer. What customers are really experiencing and how we are really managing any issues should be a core competency of the D2C streamer, who will ultimately be distinguished in the market based on service delivery, not just content.