Assuring Multi-Screen Video Quality

Challenges can be overcome with a sharpened focus on the quality of the customer's actual viewing experience on each video device, not just the performance of the network delivering the pictures and sound. Only then will network operators be able to put service quality issues behind them and carve out a significant role in the emerging multi-screen universe.

The debut of the multi-screen video era

With the unveiling of the TV Everywhere partnership between Comcast Corp. and Time Warner Inc. in June 2009, the multiscreen video era formally began. For the first time in the history of the video entertainment industry, two prominent service and content providers promised to take high-quality TV programming far beyond the conventional home TV set. Breaking the industry's traditional shackles, Comcast and Timer Warner vowed to deliver their programming to a vast array of other video displays, such as personal computers, laptops, notebooks, video game consoles, iPads, mobile phones, and other portable devices.

The embrace of this so-called "three screen strategy" by video service and content providers highlights the growing importance of digital video quality. More than ever, high-quality digital video signals are critical to the success of service providers as they seek to differentiate themselves from their competitors. With their programming now playing on multiple screens for the consumer, providers face even greater public exposure to any lingering video and audio problems on their networks.

But digital video quality is not a new issue for cable operators, telcos, and satellite TV providers. Rather, the expansion to multiscreen video simply compounds the existing quality challenges that video providers have faced for years. In fact, these challenges date as far back as the pay TV industry's transition from analog video to digital video a decade ago, as well as the industry's more recent transition from RF-based delivery methods to IP-based delivery methods.

Fortunately, video service providers need not reinvent the wheel to address the quality challenges raised and compounded by the multi-screen video environment. Even though it might seem that special gear would be needed to monitor and measure streaming media signals, no new quality assurance solutions are required.

By relying on the same tried-and-true techniques that they use to deliver video over IP to the TV set, service providers can seamlessly extend their networks to deliver video to the PC and wireless devices. By leveraging the proven methods of strategically located, continuously monitoring probes that report the status of all programs to a centralized management system, they can easily adapt such approaches for the three-screen world.

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And by deploying a strong, comprehensive, end-to-end monitoring system on their existing video delivery networks, they can future-proof those networks for the expansion to multiple display devices.

So, from the quality monitoring and assurance perspective, three screens are nothing new. The same quality assurance technologies that are deployed for digital video and IPTV can, and should, be deployed for multi-platform TV as well. By extending these tools beyond their traditional delivery systems, video service providers can enhance their ability to troubleshoot and minimize picture and sound problems, greatly reduce their operational expenses, and scale their networks even further.

This white paper will examine these service quality issues as multi-screen video moves to the forefront of the pay TV industry's priorities. In particular, the paper will show how online and mobile video monitoring and assurance do not pose any great, unique challenges for service and content providers, assuming that the providers apply the lessons learned from their initial transition to digital video transport. Rather, the addition of these new screens merely highlights the existing challenges of running high-quality video programming from one end of the network to the other and beyond.

This paper will also spell out the promising opportunities offered by the latest technical standards and techniques for tracking and insuring video quality. In particular, it will explore the potential benefits offered by the Society of Cable Telecommunications Engineers' (SCTE's) new program availability performance targets for customer satisfaction, which use innovative quality of service (QoS) metrics to address the viewer's quality of experience (QoE).

Tackling the video service quality challenges

Over the past year, more than a dozen video service and content providers on both sides of the Atlantic have unveiled plans for multi-screen video ventures. The activity has been particularly frenzied on the North American side, where AT&T, Bell Canada, Comcast, DirecTV, Dish Network, Rogers Communications, Time Warner Cable, and Verizon Communications have all either introduced or begun testing multi-screen offerings.

In fact, as Light Reading found in a casual poll of network operators during a Webinar last fall, most major North American pay TV providers are looking to launch a multi-screen service by the close of 2011. Figure 1 outlines the 16 biggest initiatives that companies have announced or reported so far.

Company	Category	Service Name	Content Partners	Business Model	Status
Comcast	Cable provider	Fancast Xfinity TV	30 networks, 2,000 hours of content	Free to current cable and broadband subscribers	Launched Dec. 2009
Time Warner Cable	Cable provider	TV Everywhere	12 networks	Free to current cable and broadband subscribers	Testing service
Testing service	Cable provider	On Demand Online	36 networks, 1,500 hours of content	Free to current cable and broadband subscribers	Launched Nov. 2009, signed up 100,000 subs
Cablevision Systems	Cable provider	PC to TV Media Relay	N/A	N/A	Planned to start tests in June 2010
Cox	Cable provider	N/A	N/A	Free to current cable and broadband subscribers	Planning service
Videotron	Cable provider	illico web	32 channels, 100s of hours of content	Free to current cable and broadband subscribers	Launched June 2010
Verizon	Telco video provider	FiOS TV Online	Epix, ESPN3, HBO GO, Starz	Free to current FiOS TV and broadband subscribers	Launched Aug. 2009
AT&T	Telco video provider	AT&T Entertainme nt	More than 12 networks	N/A	Testing service
Bell Canada	Telco video provider	TV Anywhere	3 networks	Free to current pay TV and DSL subscribers	Launched Oct. 2009
DirecTV	Satellite TV provider	N/A	In talks with programmers	N/A	Planning service
Dish Network	Satellite TV provider	N/A	N/A	N/A	Planning service
ESPN	Cable programmer	ESPN3	Own sports content	Free to broadband subscribers	Launched 2007
Hulu	Online broadcast TV aggregator	Hulu	ABC, Fox, NBC, and more than 12 other networks	Free to Internet users	Launched March 2008
Epix	Online film aggregator	Epix	Lionsgate, MGM, Paramount	Extra fee for FiOS TV subs, exploring other models	Launched Oct. 2009
HBO	Cable programmer	HBO GO	Own film and TV content	Free to FiOS TV and Internet subscribers	Launched Feb. 2010
Showtime	Cable programmer	N/A	Own film and TV content	N/A	Planning service

Figure 1

As Figure 1 shows, both network operators and video content providers are clearly intrigued by the promise of multi-platform video. That explains why so many leading cable operators and other service providers are scrambling to develop and deploy multi-screen TV fare.

But as this scramble ensues, what may be overlooked are the existing video quality challenges compounded by TV Everywhere-like services, with their multiple video playback devices with multiple formats and multiple bandwidth requirements operating in multiple locations. It is crucial that these quality challenges be addressed and overcome for network operators to succeed with their multi-screen offerings.

Why is this so crucial? The prime reason is that consumers will be increasingly unforgiving if the video programming they are seeking is not available whenever and wherever they want it, no matter what the medium of delivery. Although consumers may not expect as high resolution video from their laptops, game consoles, and cell phones as they do from their home TV sets right now, these expectations will likely rise higher as the multi-screen market grows and traditional pay TV providers plunge into it. And those quality expectations will particularly rise higher if network operators attempt to charge separate extra access and/or higher subscription fees for delivering programming to multiple devices, as has been suggested.

In an oft-quoted study conducted by TubeMogul, for example, slightly more than 81 percent of online video viewers chose to click away when they encountered either slow load times or video "re-buffers." Accustomed to nearly instant video delivery on their TV sets, most viewers simply will not wait for the video quality issues to be resolved.

At the same time, consumers will likely be increasingly willing to pay for better pictures and sound as time goes on. As the consumption patterns of over-the-top (OTT) video streaming to laptops, game consoles, set-top boxes (STBs), and next-generation TV sets have shown, viewers will put up with mediocre or even poor video quality if they like the programming enough.

But they may well pay more for that same programming, if it is delivered crisply and clearly with few glitches.

Plus, as the multi-screen video market matures, service providers will undoubtedly seek to differentiate themselves more and more on video quality issues, just as they are now doing in the TV space. If every network operator is able to deliver more or less the same video programming to consumers, then picture and sound quality may offer the best, if not the only, way for them to compete for customers.

As noted earlier, the quality issues raised by multi-screen video are not new in many respects. But as network operators gear up to deliver video programming to a multitude of other playback devices, they will be wading deeper into the already complex thicket of service monitoring and assurance issues. As much as they might wish otherwise, it is not like just adding another premium customer or household to their existing video distribution network.

Multi-platform TV introduces a whole host of new encoding processes, network segments, transport methods, and interface points where many more faults and errors can be introduced into the distribution system, causing numerous things to go wrong.

With service providers already facing serious challenges delivering high video and audio quality to home TV sets over their existing networks, these additional demands and points of vulnerabilities threaten to overwhelm providers unless they have comprehensive, end-to-end quality assurance systems in place.

Clearly then, there are numerous obstacles that network operators must overcome before they can realize their multiscreen dreams. In this section, we will spell out the various ways that video quality can, and frequently does, go awry, especially with multiple screens in the mix.

In exploring the quality problems that can occur, it is helpful to break down a video delivery network into three basic planes: *transport, content,* and *control.*

Figure 2:
Three Planes of a Video Delivery Network

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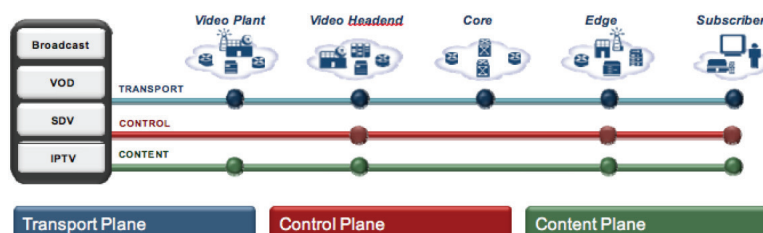
Many video and audio quality problems fall into either the transport plane or content plane camp, while a few could happen in either plane. Some typical transport plane issues include such impairments as dropped or out-of-order packets and variable timing delays in the network. For viewers, these issues can produce brief network outages or delays, momentary audio dropouts, picture macro-blocking, and freeze frames, among other problems.

To cite one prime example, MPEG packets can be lost or misplaced in one or more segments of the transport network. Or the MPEG transport stream can be altered at multiple processing points where aggregation, compression, or transport interface conversions occur.

The size of the error need not even be that great. In networks that use highly compressed video streams, for instance, the loss of just a single, uncorrected packet can produce an annoying picture problem for the viewer.

Content plane issues take in many of the other obvious video and audio problems that viewers can see and hear. The list includes server failures, blank or black screens, frozen frames, wrong program feeds, picture breaks, lip sync errors, too low or high audio, missing program information, and no audio at all, among others.

Other quality issues walk the line between the transport and content planes, depending upon the specific source of the problem. To cite three common examples, blocking events, content feed impairments, and set-up problems can all be caused by errors in either plane. Thus, it really pays to pinpoint which plane is the guilty party so that the issue can be resolved quickly and expenses can be minimized.

Of course, things can go awry in the control plane, as well. When subscriber requests for channel changes do not go through, or on-demand programs do not get served up properly, or channels do not get switched, the control plane is at fault. So a useful quality assurance system should provide enough information to detect the error, as well as identify which plane and, ideally, which component is the source of the problem.

Video quality issues do not always turn out to be what they appear to be. And occasionally the source of the errors simply cannot be determined, no matter how much sleuthing the service provider does. So there are times when network operators must try to resolve video quality problems without even knowing what caused those problems in the first place.

"At times, I feel a little bit like Columbo," said Dave Higgins, VP of quality assurance for Comcast Media Center, speaking on a digital video quality panel at the SCTE Canadian Summit in March. "You get the [customer] phone call and you're like a detective. You get these problems that just go on and on and on for weeks and, in some cases, months."

As might be expected, online video and mobile video introduce further potential complications into the delivery chain. For instance, mobile video relies on a delivery mechanism, such as Apple's HTTP Live Streaming protocol, that is different from what is typically used in today's service provider video networks.

Specifically, HTTP Live Streaming encapsulates the MPEG transport stream into separate file segments that get reassembled on the mobile device. This process can be complicated even further when the file segments are distributed first across a content delivery network (CDN), such as Akamai, and then over low-bandwidth and varying-bandwidth wireless data networks. Without the right quality monitoring solutions and components in place, service providers can be literally flying blind when it comes to detecting and isolating faults. Most importantly, providers may not be able to connect directly to the mobile subscriber that is probably in transit to gauge the current video quality and see if the subscriber is experiencing any problems.

Given the potential for compounding today's existing video quality problems and extending them far beyond the TV set to the online and mobile environments, the prospects for delivering high-grade TV Everywhere-like services may seem daunting. But as we suggested earlier, there are quality assurance solutions already in place that can help providers to rise to the multi-screen challenge.

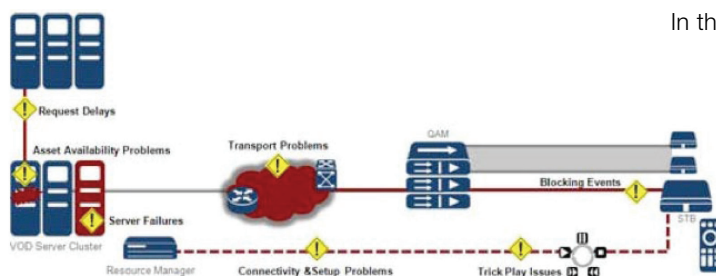In the next section, we will run through those solutions.

Figure 3:
Potential VoD Control Flow Problems

Ensuring high video service quality

Despite the many possible pitfalls of multi-screen video service, pay TV providers need not throw up their hands in despair. As we will explain in this section, there are some critical steps that network operators can take to meet the additional video quality challenges of multi-platform TV and overcome the numerous hurdles that lie in the way. Plus, with the SCTE having recently established new QoS metrics that address the quality of the viewing experience, service providers now have more ways of tracking and improving quality problems than ever before.

First of all, service providers should ideally boost their ability to monitor all phases of their ever-growing video delivery networks. Rather than monitor video quality just at the headend or on the network or at the subscriber's home, they should track the video quality at every demarcation point along the way from one end of the network to the other. Only such thorough end-to-end system monitoring with specialized hardware and software probes will provide a clear picture of all the problems that might arise, particularly as operators expand their distribution reach to the new playback devices and to multiple locations. Indeed, video and transport quality must be verified at all critical interface points, as well as at the viewer's location.

"If you're not using a monitoring platform presently, then go out and get one because you have no idea what's happening," urged Stephen Shaw, a digital cable engineer for Cogeco Cable, speaking at the SCTE Canadian Summit in Toronto. "You need to monitor this stuff. You've just got to do it." He argued that such a platform probably "pays for itself in the first two months."

Secondly, cable operators and telco TV providers should ensure that they monitor all three planes of their video delivery networks comprehensively, not just one or two. If they do not monitor all three planes, they will surely miss some crucial errors and have limited ability to correct them promptly. Plus, they will shell out more money on wasted service calls and technician visits, which can cost as high as $5 per call and $150 per truck roll.

Next, network operators should establish relevant alarm thresholds for their monitoring tools. The key is to gain as much visibility into the network as possible so that all faults can be detected and the causes can be rooted out. But the thresholds should not be set so low that the alarms end up going off all the time.

For instance, momentary media loss for one second over a four-hour period might not be worth all the trouble to resolve because the problem is so slight and has run its course by the time it is viewed. So while it is important that all video errors can be detected, they may not all be serious enough to be noticeable or actionable.

Indeed, as Cogeco Cable pointed out in a technical paper presented at the SCTE Canadian Summit, setting alarm thresholds at the right levels "appears to be a fine art. Tweaking the appropriate thresholds in order to provide useful notification proved to be more difficult than was imagined." But after some trial and error with setting thresholds, Cogeco eventually reached a happy medium and "created a new configuration that would alert only on customer-impacting events lasting more than a predetermined duration."

Just as importantly, network operators should choose meaningful metrics for tracking faults on the various planes. Without such warning metrics, they will not be able to find out what is really going wrong on their networks and fix the problems promptly.

In particular, digital video providers should establish meaningful, objective QoE thresholds for network uptime. With such easy-to-understand metrics, they can then set about the work of tracking, measuring, and improving the customer's actual viewing experience.

This task is not as easy as it might sound. Mark Shinozaki, director of network quality assurance for Rogers Communications, attested to this fact at the SCTE Canadian Summit. The "major challenge," he said, is that "it's difficult to link the customer experience with network metrics." He noted that Rogers has sought to do this by embracing "customer-based metrics," including reductions in the number of customer complaint calls and technician truck rolls.

Fortunately, the SCTE recently crafted a significant new QoS metric for stream uptime that ties in directly to the viewer's QoE. This new standard, which is known as "SCTE 168-6 2010 Recommended Practice for Monitoring Multimedia Distribution Quality," addresses QoE by setting an objective network performance target for program availability. Part of a trio of new network performance standards that the SCTE published in late March, it uses the number of "errored seconds" in a program to gauge whether there are too many errors in the video delivery and whether the subscriber's viewing experience may be affected.

Specifically, SCTE 168-6 2010 sets "high program availability" targets for operators, expressed in terms of the numbers of errored seconds that viewers might experience over a 24-hour period. On a per-channel basis, the established targets are 24 or fewer errored seconds over 24 hours for standard-definition (SD) broadcasts and six or fewer errored seconds over 24 hours for high-definition (HD) programs. Expressing these targets as a percentage of monitored seconds, that comes out to a minimum of 99.993 percent program availability (or "four-nines") for each channel.

Figure 4: SCTE's Proposed High Program Availability Targets

Transport Type	Stream Bit Rate	Loss Distrance
SD/MPEG2	3.75 Mbit/s	<24 errored seconds/day
HD/MPEG2	15.0 Mbit/s	<6 errored seconds/day
SD/MPEG4	2.0 Mbit/s	<24 errored seconds/day
HD/MPEG4	8.0 Mbit/s	<6 errored seconds/day

The SCTE's "high program availability" standard is superior to the older network "high availability" target, because it represents how viewers will be affected by a fault. Unlike the high availability network performance standard, which focuses on the network's uptime performance, the program availability standard focuses on the customer's actual viewing experience. Indeed, a network could be 99.999 percent available, yet deliver just an 87.123 percent available video experience to viewers, because of dropped packets or jittered packet delivery. That is, the network could still be delivering packets all of the time, earning it an "up" qualification; while at the same time, the packet error rate could be excessively high, producing an impaired viewer experience.

The new SCTE standard provides clear, common language that all parties in the video delivery chain — including service providers, content providers, and equipment manufacturers — can easily understand. This allows video service providers to cut through the complexity of monitoring and managing the performance of their operations teams, and the entire video network.

Notably, the 99.993 percent availability standard places the focus on the performance of the TV programs, not the performance of the underlying delivery network. All of the faults are correlated on a per-program basis. Thus, network operators can concentrate on tracking, troubleshooting, and improving the customer viewing experience above all else, just as they should.

This concept of maximizing program availability for viewers will only become more essential over time as pay TV providers ramp up their online video and mobile video expansion efforts. To remain competitive and keep churn levels down, network operators must zero in on what customers actually see on all their various video playback devices, not what it appears that their networks are delivering.

Of course, each service provider must address its unique network needs at its own pace and in its own fashion. Due to the different types of network topologies that each company may have and the different levels of quality standards that each company may choose, no single cookie-cutter solution will work for all providers. But it is quite possible for network operators to meet the great multi-screen video service quality challenge, as long as they know the right things to measure, use the right tools for measuring them, cover the right places with those tools, and set the right thresholds for evaluating them. They also need to shift their emphasis on network performance so that viewer QoE, not merely QoS, becomes their paramount concern.

Conclusion: end-to-end QoE

As we have seen, video service quality is a critical, if often overlooked, ingredient of success for pay TV providers. Although the quality of the video service does not get noticed all that much when everything is going well, it stands out sharply as an issue whenever viewers run into picture or sound problems. As a result, service quality can be a key differentiator for network operators as they strive to compete for new customers and retain their existing ones while controlling or even reducing operational costs.

With the multi-platform TV era now beginning in earnest, video service quality will only become a more pressing priority for network operators. Subscribers will increasingly demand higher quality as the market grows and they turn to their trusted multichannel video providers for service. And competitive pressures will increasingly force video providers to try to distinguish themselves on quality standards in the emerging multi-screen arena, just as they are increasingly seeking to differentiate themselves now on the more mature home TV front.

To be sure, network operators face a raft of video quality service challenges as they prepare to make the historic shift from the home TV set to multiple video screens.

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These daunting challenges range widely across the transport, content, and control planes, from processing and distribution errors to control flow issues to other thorny network and transport problems.

But these challenges are not much different from the challenges that service providers already face on their existing video delivery networks. While multi-screen video delivery may compound their existing service quality problems and add some new twists and turns to them, it does not change the fundamental nature of these problems.

Therefore, just as in the legacy one-screen world, these challenges can be overcome with an intensified end-to-end network approach, one that emphasizes monitoring the video delivery network from digital headend to playback device while making sure that all of the points along the way are well covered. These challenges can also be overcome with a sharpened focus on the quality of the customer's actual viewing experience on each video device, not just the performance of the network delivering the pictures and sound. Only then will network operators be able to put these service quality issues behind them and carve out a significant role in the emerging multi-screen universe.

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