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SPECIAL SUPPLEMENT



Maximising IPTV video quality

through the effective use of Test, Measurement and Monitoring



Video quality isn't just a luxury, it's a necessity...

Robert Winters is the co-founder and Chief Marketing Officer of Shenick Network Systems. He had a lot to say about video quality when we caught up with him recently.

IPTV News:

We're hearing more and more about video quality. To you, what does that mean?

Several of our customers have told us that after their first surge of new subscribers -- who came to them for the programme selection and the service offer -- many have left due to poor video quality. This means that test and monitoring are revenue loss prevention systems, period.

Can you provide an example?

We have been working with one large and long-deployed European Operator with hundreds of thousands of subscribers that contacted us because they had lost more than 10% of their base. This one was very interesting because the Operator's marketing department initiated -- and is funding -- what they call their quality assurance project. Usually, the funding for test and monitoring are buried somewhere in the network operations budget.

What is this Operator doing, then?

They actually have decided to measure every DSLAM in the network. Not every Operator goes that far, but it shows a serious commitment to delivering consistent quality. And it proves that the issue of quality is real and it has real impact on the Operator

So, to them, video quality is mission critical...

Absolutely, and we see game-changing examples all the time. In fact, speaking of games, the "video referee" used when our Irish rugby team was playing Italy was suffering so badly that when they went to the replay to resolve a dispute, you couldn't see where the ball landed in the video, so they had count on the powers of human observation to call the play



Other than maintaining video quality, what have been your customers' biggest issues?

Certainly one is OpEx. Our customers want to prevent truck rolls by better pinpointing problems. They don't want to send people into the field not knowing whether the problem is at the output of the headend, in an aggregation node or at a DSLAM -- and run the risk of sending them to the wrong place. Tying this back to the consumer, some Operators have adopted a practice of putting up a screen that tells subscribers they are having technical difficulties and how long the outage will be. Better pinpointing gives better estimates, and helps subscribers be more patient.

The need for containing expenses is clear. What else?

Most video issues today center around multicast TV, but the combination of the rise in personalised TV -- which means unicast -- along with the need to scale, means that bandwidth requirements will certainly increase. Therefore the Operator has to be able to anticipate the required capacity ahead of time so as not to over-engineer or under-engineer the network. How many customers can I deploy on this access node before quality suffers? With test and monitoring, they can run scaling scenarios in the lab until something breaks.

Test, Measurement and Monitoring has been something of a stealth topic until recently. How is it impacting Operator budgets?

It's interesting because you would expect it to be a difficult sell. But the impact of buying test and monitoring has been to help them manage expenditures by managing expectations. Operators can know their infrastructure's performance limitations before it reaches those limitations unexpectedly in service. It helps them plan for their investments and therefore more accurately forecast future capital expenditures.

Maximising IPTV video quality

through the effective use of test, measurement and monitoring

Because high content quality and bandwidth management are so important to IPTV Service Providers intent on capturing and keeping subscribers, the Test, Measurement and Monitoring (TM&M) market is becoming a major focus of attention and innovation. Steve Hawley, Senior IPTV Analyst, Multimedia Research Group (MRG) Inc identifies the issues and suggests solutions to help Operators overcome the challenges of video quality.

IPTV service Operators and their suppliers have progressed far in developing and deploying IPTV infrastructures to deliver video services to residential broadband subscribers, and now are increasingly focused on refinement.

A variety of areas help IPTV Operators differentiate themselves from cable and satellite TV competitors. One of them is to have an equal or greater range of content, including HDTV and local programming. Another is the effective packaging and bundling of content, and yet another is the Telco's ability to bundle TV and non-TV services together and offer them at a competitive price. But without a consistently high-quality, high-performance video experience, it becomes more difficult for IPTV Service Providers to build a compelling justification for consumers to subscribe to the service, and to keep them loyal and may make or break the Operator's ability to capture the higher ARPU (average revenue per user) that comes along with TV.

What Exactly is Video Quality?

Simply stated, IPTV video quality is made up of three interdependent components:

- Video Quality (VQ): the quality of the video content itself, including chroma, luma, and picture resolution
- Quality of Service (V-QoS): the presence or absence of errors arising from delivery through the Operator's facilities to the customer premises over the broadband wide area network, and within the consumer's home network
- Quality of Experience (QoE): the quality of the delivered video along two dimensions: human perception and performance

QoE is highly dependent upon QoS. When QoS errors develop, QoE risks include unwanted image artifacts, loss of picture clarity, picture blockiness, momentary blackouts, loss of metadata and synchronisation of audio and video.

Why Video Quality is Important?

If, as the adage goes, "content is king," then it's equally true that video quality is queen. Only by ensuring high levels of all three aspects of video quality – VQ, QoS and QoE -- can IPTV Service Providers begin to capture new subscribers and keep them loyal.

High-quality IPTV delivered over a managed network is a zero tolerance environment: either the video is working or it is not. Even the tiniest of errors can have highly visible results, and service outages can be catastrophic; in that repeated errors and outages can cause subscribers to abandon the service.

What is IPTV Test Measurement & Monitoring?

Test, Measurement and Monitoring (TM&M) is a broad product and technology category that provides Operators with the objective and subjective feedback that they need to help them ensure the optimal level of quality for their content delivery and communications services.

But also, test, measurement and monitoring are actually three closely-related functions:

- Testing is a pro-active on-demand process, done both at key points where data changes hands, and at a system-wide level. Testing usually involves "probing," which is the sending of bit stream traffic into some or all of the IPTV delivery chain for subsequent measurement and monitoring, to identify and isolate faults or failures. Reactively, testing helps pinpoint faults after they occur in the commercial deployment. Testing also helps Operators qualify new equipment and locate choke points that can impact quality.
- Measurement is the process of detecting and recording the impact of bit stream traffic generated by test equipment or test processes, across the end-to-end IPTV delivery chain, or within individual domains or subsystems. Most measurement solutions compare actual traffic with idealised parameters established by standards and/or by the Operator. It may be performed at a data traffic level and/or on the media content itself.
- Monitoring is an ongoing process of "watching" what is happening in the IPTV system. Generally speaking, active monitoring is a process of generating test traffic into the network, and comparing between source and received data. Passive monitoring is a process of listening for faults. This can be done before, during and after deployment, both in the lab and in the actual production system.

To get the most out of the IPTV deployment, Operators must do all three

What Does TM&M have to do with Video Quality?

In terms of benefit, TM&M constitutes a way to help assure that IPTV services are delivered with high quality, without interruption and with a minimum of errors; ensuring that picture quality and application performance are at their best, and helping the Operator maintain consumer loyalty.

For Operators, TM&M involves a process of establishing performance metrics and error tolerances relating to delivery and application performance for video and other services, through which the Operator can gain sufficient knowledge to keep service quality and performance up to the Operator's established parameters. These parameters may be informed by technical standards defined by industry organisations and standards bodies, developed by Operators themselves – or both. If IPTV middleware constitutes the brains of an IPTV operation, then Test, Measurement and Monitoring provide a nervous system.

Positive Impacts of IPTV TM&M

Subscriber acquisition, retention and increased ARPU are just one part of the overall IPTV service equation. Equally important is the fact that Operators are always on the lookout for ways to reduce operational expenditures relating to service, and for ways to streamline and cost-reduce the process of acquiring new IPTV

infrastructure; from the headend, through the network, to the CPE – and now, within the digital home and across multiple device and service platforms.

The ability to test and monitor IPTV video quality – before and after the deployment goes into commercial service -- helps the Operator optimise systems and network design, pinpoint the causes of video quality problems, lower the cost of field service and even help Operators pre-qualify new equipment; all of which serves to help the Operator avoid significant costs over the life-cycle of the deployment.

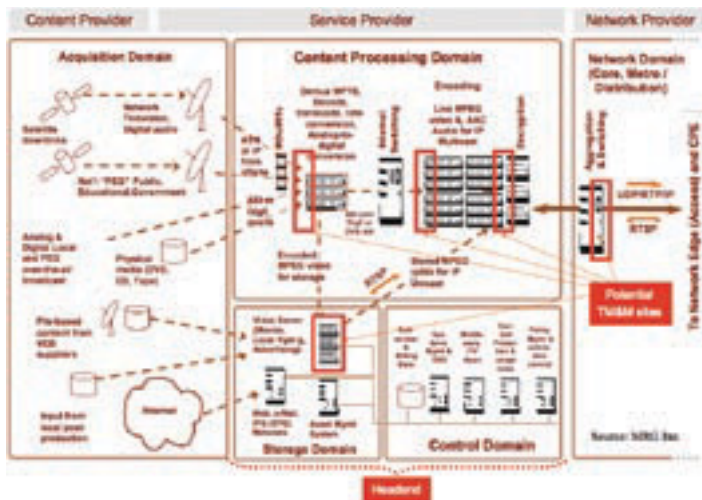
Where are Testing, Measurement and Monitoring Done?

Operators implement a testing infrastructure at places where content and data change hands. Because the IPTV delivery chain is complex, it is useful to break it down into segments. Standards organisations such as ATIS and the ITU define separate domains for content providers, Service Providers, the network provider and the consumer. MRG breaks it down further, identifying separate areas for content acquisition, content processing, storage, control, distribution, the network edge and the customer premises.

In either case, each area has its own needs when it comes to TM&M implementation.

Figure 1: Shows the potential locations for test, measurement and monitoring solutions at areas where video is acquired, processed and distributed. At the headend, for example, source video can be sampled to provide a reference point for video that is sampled downstream for purposes of comparison.

Figure 2: Potential placement of TM&M equipment between the headend and the network edge



Source: Copyright © 2008 MRG, Inc.

During the process of distribution and at the network edge, errors can be introduced in transmission due to bandwidth limitations, while at the customer premises, noise may be introduced due to degradation of wiring from the curb or in the home itself.

Figure 3: Shows potential TM&M points in the network edge and customer premises domains.

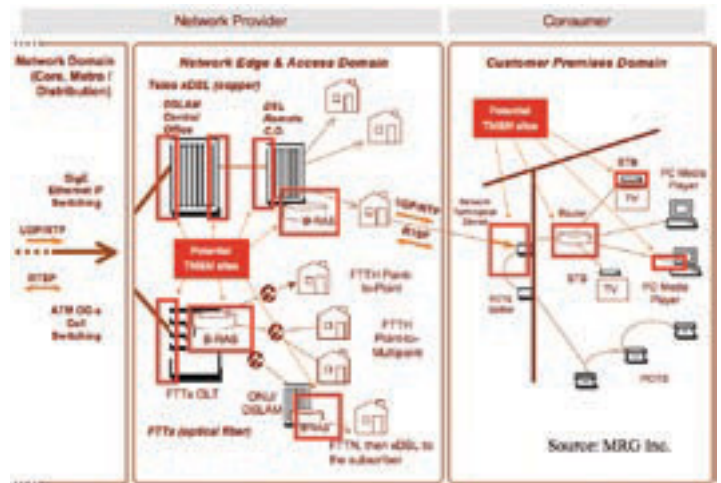


Figure 3: Potential placement of TM&M equipment from the network edge into the home

Source: Copyright © 2008 MRG, Inc.

One thing not shown in Figure 3 (above), but also important, are the use and placement of test devices used on a reactive basis, to identify and isolate problems during a service call. In those cases, a variety of portable and handheld devices are available for use by field technicians dispatched to troubleshoot for problems in the network and at the customer premises; and hopefully fix them.

What is "Video?"

Video is evaluated at four levels: the quality of the video itself (VQ), Quality of Service, the integrity of the video stream and Quality of Experience. To better understand the underlying principles both for digital video and to understand how IPTV test, measurement and monitoring work, it is worthwhile to have a basic technical understanding of the structure of the video content.

Video content distributed in most modern TV deployments, IPTV included, is in one of the digital broadcast video formats defined by the Motion Picture Experts Group (MPEG); either as MPEG-2 or MPEG-4.

MPEG video transport streams are created through an encoding process that "compresses" the video by deliberately discarding data. There is a classic trade-off between compression, which allows more content to travel over the network at lower speeds, and video quality, which must be as good as possible. TM&M equipment helps the Operator understand the value of this tradeoff, and to optimise video delivery for highest quality at lowest the lowest possible speed. The speed typical of MPEG-2 encoding is about 3.75mbps for standard definition television, and about 12-14mbps for HDTV. For MPEG-4, these rates decrease by roughly half. By comparison, an uncompressed standard-definition ATSC video signal is about 20mbps.

Figure 4 Shows the structure of an MPEG transport stream

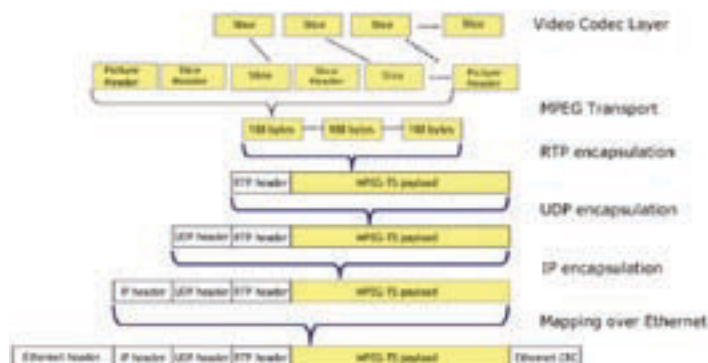


Figure 4: Structure of an MPEG transport stream.

Source: Shenick Network Systems.

The transport stream is segmented into a header and a payload. The header contains information pertinent to transport and routing, while the payload is made up of Groups of Pictures (GOPs), in turn made up of image frames. Each image frame is segmented into 16 x 16-pixel units called "macroblocks."

How do Test, Measurement and Monitoring Identify Problems?

As you see in Figure 4 (above), an MPEG transport stream contains so much information that even the smallest transmission error can result in visible damage to the video experience. IPTV video is impacted by packet loss, packet delay, missed/dropped packets and variations in packet delay (aka "jitter"), which are the core metrics by which video QoS is measured.

The integrity of the video stream is determined by whether it is intact, or has lost enough information through packet loss that the video cannot be accurately reconstructed at the receiving end of the IPTV delivery chain. This results in visual artifacts in the video display or dropped video frames.

Earlier, it was stated that QoE has two components: perceptual quality and application performance. Perceptual quality is measured using a metric called the Mean Opinion Score (MOS). A MOS score is determined by algorithms that simulate the judgments of actual human subjects that rank video from 1 (lowest) to 5 (highest). Typical IPTV deployments strive to exceed MOS scores of 4.5. There are MOS determinations for video, audio and the combination of audio and video.

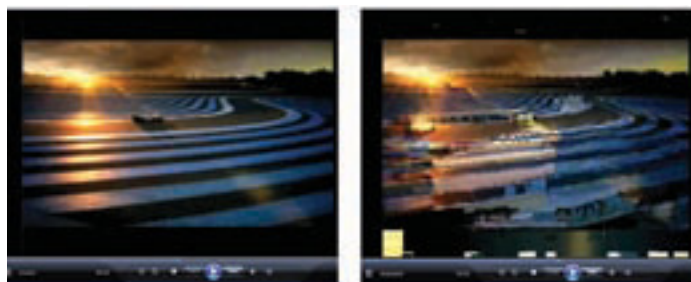
Additional QoE metrics that include channel change (or "zapping") interval, which is managed by IGMP, the Internet Group Management Protocol, which governs the process of joining and leaving a multicast channel that has been delivered to the network edge. Another important QoE measurement is associated with the Realtime Streaming Protocol (RTSP), which governs "trick-play." Again, Operators must be in a position to measure the delay times associated with on-demand requests, such as video playback, pause, fast-forward, and so on, so the Operator knows when performance falls outside of acceptable limits.

An additional QoE consideration is the ability to compare source video to video sampled across the delivery chain, and there are several methods for doing that which are described by technical standards. In addition, there are several approaches to analysing MPEG content: to analyse the headers only or to analyse both the headers and content.

Video errors can occur as early as the encoding process, when the Service Provider converts the video content acquired at the headend into an MPEG video stream, through overly-aggressive encoding, but the errors that concern Operators more greatly occur in the network and at the customer premises. One example of a video error is shown in Figure 5 (below), which compares a source picture with a degraded one.

Figure 5: Comparison between a source video frame and a degraded video frame

Source: Shenick Network Systems.



The lefthand frame in Figure 5 (above) is the source signal while the one at right shows the same frame when packet loss is occurring in the network.

The active PEVQ MOS score in this sample video was low, with high rates of jerkiness, blurriness and blockiness.

Another way to look at video quality is to consider the depth of analysis that the Operator wants to perform, reflecting the level within the IP stack at which the analysis occurs. QoS and QoE measurements can easily be mapped to match the OSI Layers, as shown in Table 1.

Table 1: Quality Test Areas' Relationship to OSI Layers

TM&M Area	OSI Layer Involved
VQ (Video Quality)	Layers 7,8
QoS (Quality of Service)	Layers 1-4
QoE (Quality of Experience)	Layers 4-7

Source: Copyright © 2008 MRG, Inc.

QoE actually is achieved through a combination of objective and subjective measurements, with objective measurements done in OSI Layers 4-7, as depicted in Table 2.

Table 2: Quality Test Areas' Relationship to OSI Layers

TM&M Area	OSI Layer Involved
Transmission and Delivery	Layers 1-3
Integrity of Packet headers & content	Layers 4-7
Perceptual quality Application responsiveness	

Source: Copyright © 2008 MRG, Inc.

Segmenting the Operator's evaluation criteria in these ways helps identify what kinds of testing and measurement are required at different points in the delivery chain, at what times, and for what reasons.

Infrastructure Design & Implementation Considerations That Help Ensure Video Quality

Because content is acquired in so many formats, it should be converted into a common (and preferably uncompressed) digital format as early as possible; and with as few occurrences of processing as possible, in order to best preserve color and image fidelity prior to encoding for distribution. Operators should be prepared for stringent picture quality requirements from the content owners.

Content should be encoded into MPEG-2 or MPEG-4 AVC format; the latter being best for Operators distributing HDTV over limited bandwidth resources. Operators should carefully evaluate the available alternatives relating to transcoding, re-encoding and encryption, taking care to use as little content processing as is practicable.

Furthermore, Operators should design their headend and network facilities with sensitivity to their current and anticipated service lineups, to help ensure that their end-to-end facilities are up to the challenge. Distribution should involve as few network hand-offs as would be practical, to further minimise the risk of video errors.

Buffering should be adequate in the set-top box to allow for error-correction prior to the video being rendered to the screen. Buffering in the network is an additional consideration for Operators that implement the Microsoft MediaRoom system.

IPTV TM&M Best Practices

Test, Measurement and Monitoring are fundamental not only to the revenue success of the IPTV deployment, but also to keeping down operational expenditures by reducing the need for truck-rolls, and it should be a key consideration throughout the life-cycle of the deployment. TM&M should be part of the initial design of the deployment, should be used for pre-deployment simulation and equipment qualification, for testing as the deployment is commissioned for commercial service, and afterward on an ongoing basis.

To gain a full understanding of video quality, testing must occur for the transmission layers (Layers 1-3) of the network, to ensure physical integrity and packet delivery. It also must occur for the service layers (Layers 4-7), including the ability to ensure the integrity of video packet headers and the video content (payload) itself, as well as applications performance and perceptual quality.

Operators seeking revenue from video and interactive services should implement full-time proactive TM&M. The selected test and monitoring solution should provide both full-time IPTV monitoring and the ability to test while monitoring the live service at the same time. This ensures that there are no disturbances to the service. Figure 6 (top right) shows a monitoring system that is doing exactly that.

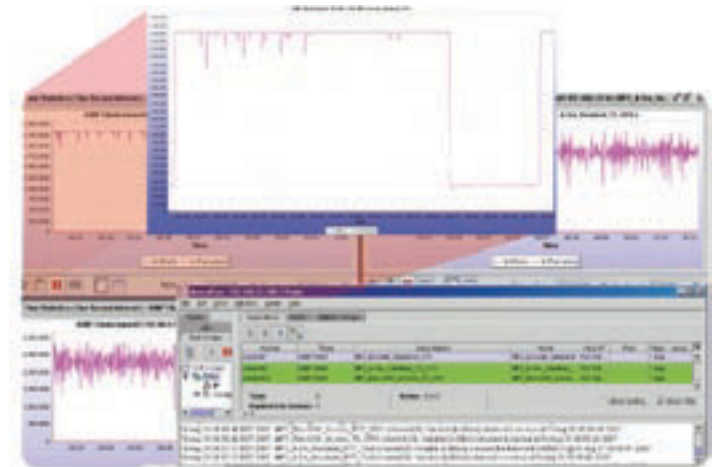


Figure 6 – Monitoring console showing full-time monitoring of TV channels

Source: Shenick Network Systems.

Service Providers looking to differentiate their service offering based on high quality video/audio content delivery, at a minimum should monitor in the headend and in the last mile – and ideally, at major hand-off points and at the customer premises. Knowing which channel variables to monitor is key to understanding the source of quality issues. Figure x.x (the following figure) shows an IPTV monitoring console that identifies a TV channel outage over black screen content. The graph in this figure shows a dramatic decrease in the signal level. This occurrence sends an alarm to the console, alerting an engineer to the occurrence.

Figure 7 – Monitoring console showing a TV channel outage over black screen content



Source: Shenick Network Systems.

The original (source) video signal should be compared with video sampled by TM&M equipment downstream in the network, using active content analysis, so that a degraded signal, such as the one illustrated in Figure 7 (in section 1.8 above) can be identified and ideally, avoided.

With respect to the MPEG video content, it is important to test measure and monitor the MPEG stream itself, including the content, and not just the headers; so that lapses in perceptual quality, as measured by MOS scores, are flagged and the Operator is alerted.



In addition to testing the video, Operators also must ensure the preservation of non-program data. This includes embedded program information, including program metadata and closed captioning data as well as content ownership-related information such as watermarks, fingerprints and business rules. Testing must be performed to ensure that encoding is not so aggressive that this embedded content suffers.

Standards for Video Quality

A lot of activity is currently underway toward the development of standards relating to Video Quality (VQ), Quality of Service (QoS) and Quality of Experience (QoE). Operators should select equipment/solutions that tests to the prevailing IPTV VQ & QoS standards. Important standards include ITU J.144, which specifies models for comparison of source and sampled video; ITU Y.1541 (IPTV QoS), DVB-IP TS 102 034 (MPEG-2 transport), Fast Channel Change in RTP (ISMA TD-00096) and Application layer forward error correction (Proposed to ITU).

QoS focuses on Layer 2-3 data communications errors, such as ITU-T Recommendation Y.1540, which specifies Packet Loss Rate (PLR), Packet Sequencing, Packet Delay, Packet Delay Variation (Jitter).

This is not an exhaustive list of standards. Multimedia Research Group has published two comprehensive reports over the past year which detail the issues and list the standards associated with video quality, QoS and QoE that are pertinent to test, measurement and monitoring.

Test Measurement & Monitoring to Reduce OpEx

The premise is simple: Operators are driven to keep costs as low as possible, and one of the highest costs of operation is in dispatching field service into the time-consuming process of troubleshooting and fault isolation. But these are exactly the purpose of TM&M; to identify and isolate the root issues from a centralised location, so field service engineers are only sent out when absolutely necessary. Imagine the cost savings if even one third of truck rolls became unnecessary.

Operators build redundancy into their deployments to ensure quick recovery from failures in the delivery chain. This philosophy of redundancy should extend to TM&M systems and to spares, so Operators aren't waiting for excessive periods that increase the risk of additional failures with no available backup testing or operational components. Outages resulting from failures clearly impact QoE.

The Operator's lab should remain in place after the deployment is in commercial service, to keep the Operator in a position to replicate and address post-deployment alarms and failures, in a controlled environment. This also minimises the need to take any elements of the live system out of service during the troubleshooting process, and reduces the need to roll trucks on hunting expeditions.

Optimising CapEx

On the CapEx side of the equation, TM&M has several important roles. For one, it can help the Operator save money by determining how much equipment would be needed in various future deployment scenarios; so the Operator doesn't over-invest (or under-provision). In addition, Test, Measurement and Monitoring can be employed in a controlled environment, but after deployment; to simulate the deployed network and pre-qualify new capital equipment & software from multiple vendors, in an effort to identify the optimal solution before committing to a purchase

for production. In many cases, the test process can identify shortcomings in the configuration of systems elements or the CPE.

It's key to evaluate vendors that offer solutions both for pre- and post-deployment, so the metrics used for each utilise the same algorithms (for example: a MOS score that reads "4.5" isn't necessarily the same from one vendor to the next)

Because the Microsoft MediaRoom platform has a uniquely specialised content distribution architecture, and has test considerations that differ from other IPTV platforms, Operators should use TM&M solutions designed for MediaRoom.

Conclusions

IPTV Operators have a special opportunity to provide high-quality video to consumers. Both satellite and cable Operators have network constraints of their own, which have an impact on video quality. Cable Operators have a 622mbps limitation (I think this figure is right) in the core network while satellite Operators have to contend with limited transponder capacity. Therefore, both types of competitors must encode aggressively, which has its cost in video quality. In addition, satellite TV is not interactive, nor can it accommodate user-generated content or the kinds of social interaction envisioned by IPTV Operators.

But only IPTV combines the advantages of interactivity and the potential for truly high video quality, and therefore a competitive advantage. However, with the emergence of switched digital video and the upgrade to MPEG-4, these advantages are becoming less dramatic – forcing Telcos to stay ahead of the video quality curve.

This makes it all the more important for Telcos to carefully test, measure and monitor video throughout the end-to-end video delivery chain, so that it arrives error-free – to help Operators keep subscribers from abandoning an IPTV service after the Operator has worked so hard to acquire and serve them in the first place.

"Multimedia Research Group (MRG) Inc recently issued the new report Monitoring and Managing QoS/QoE for IPTV – 2008 as a follow-up to its IPTV Video Quality: QoS & QoE report published by in 2007. The report provides an in-depth analysis of the emerging IPTV TM&M (Test, Measuring and Monitoring) category of technologies and products, and details the concepts, best practices and recommendations listed in this article, plus many more.

ATIS = Alliance for Telecommunications Industry Solutions, which has developed standards recommendations for IPTV systems architectures, Quality-of-Service, middleware and other areas

ITU = the International Telecommunications Union, whose IPTV focus groups have acted to consolidate the recommendations of ATIS, Operators, vendors and other standards organisations into a broad set of IPTV standards.

Advanced Video Coding, also known as ITU H.264 or ISO/IEC MPEG-4 Part 10

What's wrong with this picture?

Nothing...

Keep it that way!

Shenick

Testing MPEG based IP video QoE/QoS Introducing Passive and Active Video Analysis. The ability to measure and monitor key parameters of an MPEG-TS including PES headers provides an indication of the video stream quality. The ability to measure RTP jitter in the transmission layers will indicate if the fixed buffers in the network, including the Set-top Box (STB) jitter buffers will over or under run, which evidently will lead to poor QoE. An important factor is video and audio quality measurements. There are two methods for qualitative video analysis. The first method analyzes actual video payload, known as Active Analysis and involve a full and detailed video reference comparison. The second method is Passive Analysis which is a real time video quality assessment by analyzing header details. Passive analysis has the added benefit of being able to determine video quality on encrypted streams

To find out more please visit our website or meet us at the upcoming IPTV World Forum events in Singapore and London.

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