White Paper

Scalable IPTV Quality Testing

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Agilent Technologies

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Network equipment manufacturers and service providers are moving quickly to develop and deploy devices that fulfill the promise of delivering voice, video and data to customers over a converged IP infrastructure. These services, collectively referred to as Triple Play, are the pillars of a new business model for service providers attempting to mitigate the effect of ever-shrinking voice revenues. Video is the key component to service providers' growth, as it enables them to compete with cable MSOs that already have video, data and VoIP offerings. IPTV revenues are expected to increase by 179% per year, reaching $44.3B worldwide by 2009 [Infonetics Research, IPTV Equipment and Services Market Outlook, November 10, 2005]. The existing network infrastructure supports a best effort model that is suited to many data applications, but is poorly adapted to demanding voice and video applications. Voice and video (IPTV and video-on-demand) have stringent Quality of Service (QoS) requirements, and meeting these requirements is a key success factor for service providers as they strive to build customer loyalty. Indeed, customers' Quality of Experience (QoE) is the key value upon which service providers must differentiate themselves: the delivery of video over IP is a nascent and highly competitive area, and for customers to truly embrace IP video, and the broader Triple Play offering, it must meet or exceed their QoE expectations. In order to ensure this high quality, equipment must be rigorously tested to ensure that it can bear hundreds of video channels destined for thousands of subscribers. Naturally, this testing must include simultaneous measurements on all video streams passing through a device or system, to guarantee that the viewing experience of all subscribers is acceptable at all times.

This paper explains why the Media Delivery Index (MDI) is uniquely suited for gauging video quality under realistic scale. The first section describes the MDI and its applications. The remainder of the paper introduces other video quality measurements which can be used to provide complementary information on video quality, although they are not suitable for characterizing networking devices in highly scaled scenarios.

Introduction to the Media Delivery Index

The Media Delivery Index gives an indication of expected video quality based on network-level measurements. It was the subject of an IETF Internet-Draft proposed in 2005. A further draft on generating MDI characteristic curves for devices in different video delivery scenarios is currently underway. MDI has gained widespread acceptance in the industry, with a number of service providers and network equipment manufacturers already employing MDI test solutions.

The Media Delivery Index has two components: the delay factor (DF) and the media loss rate (MLR).

Delay Factor

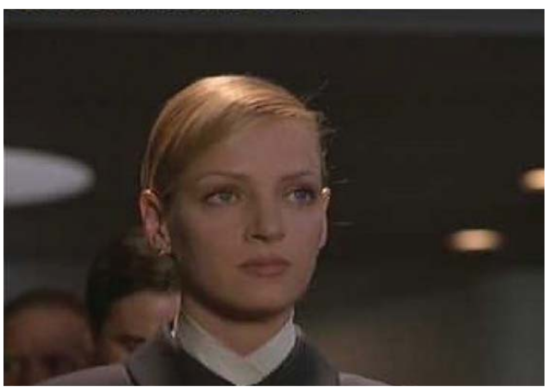
One of the enemies of good video quality is variation in packet inter-arrival time, or jitter. Excessive jitter can lead to packet loss, which can cause jerky playback or introduce visual artifacts into the video, thus degrading the user's QoE. Since video decoders typically consume data at a constant rate, packets arriving at a variable rate must be buffered before the stream is presented to the decoder. Buffering also occurs at network elements between the video source and destination, as media packets are queued and await their turn on the device egress interface. The more jitter that is present in a media stream, the larger the buffers must be to compensate for it and prevent packet loss. Large buffers can eliminate jitter, but this is done at the cost of adding delay to the stream. The delay factor quantifies this delay by specifying the size of the buffers (in milliseconds worth of data) required to deliver video at the desired rate, in the presence of jitter. If the buffers are too small, two unfavorable situations can arise: overflow and underflow. An overflow occurs when packets are arriving at such a high rate that they fill the buffer and cause packets to be dropped at the receiver. An underflow condition exists when packets are arriving so slowly that the data accumulated by the buffers has all been consumed by the decoder.

Media Loss Rate

Any media packet loss has the potential to adversely affect video quality. Notwithstanding decoder error concealment techniques and codec resiliency schemes, packet loss in video delivery networks is undesirable. In MDI, packet loss is represented by the media loss rate (MLR). MLR is simply defined as the number of lost or out-of-order media packets per second. Out-of-order packets are of importance because many consumer devices, such as Set Top Box decoders, make no attempt to reorder packets. A non-zero MLR implies that video quality may be degraded with visual impairments or irregular and uneven playback.

Figure 1 shows the same video delivered by two different service providers. Which one would get your business? The answer to this question will fundamentally determine the future of each provider and their network equipment suppliers. This is the reason network equipment must be tested under realistic conditions to determine whether it can deliver quality video to paying subscribers.

Figure 1: Contrasting video screenshots from different providers. The MLR can be used as a predictor of video quality.



(a) Provider #1: Unimpaired video screenshot. MLR = 0

(b) Provider #2: Video screenshot in the presence of packet loss. MLR > 0

Testing Network Equipment Using MDI

MDI is very well suited to testing network equipment (e.g., ATM and Ethernet switches, EARs, BRASs, IP DSLAMs, etc) used in a video delivery infrastructure. Because MDI is a lightweight calculation, it is feasible to perform simultaneous near-real-time measurements on the hundreds of video streams passing through a device on their way to thousands of subscribers. This is key, because one vital element of the testing is to ensure that all subscribers receive the expected QoE. This can only be achieved with a scalable measurement such as MDI. The real-time aspect of the measurement is valuable in correlating video quality to test-network conditions at a given time. It is also important in the context of monitoring applications.

Because the MDI relies on packet-level measurements, it is independent of the video encoding technology. Hence, it can give an indication of how the system under test affects video quality for MPEG-2, MPEG-4, MPEG-7, and Windows Media 9 (VC-1), as well as proprietary and encrypted schemes, without the need for knowledge of the codec's inner workings.

The MDI's components are based on concepts that translate directly into networking terms: delay and loss. This is convenient for isolating problems and determining their root cause. A high delay factor directly indicates that increased latency, which can degrade video quality, has been introduced by the system under test. It also warns of possible impending packet loss, as device buffers approach overflow or underflow levels. This points to congestion in the network or inadequate buffer resources as potential reasons for the poor performance. Similarly, the MDI's media loss rate component clearly highlights packet loss events as contributors to poor video quality. This provides much greater insight into the network conditions that contribute to video quality than, say, a simple video quality score on an arbitrary scale.

Complementary Measurements

While MDI is clearly the measurement of choice for testing network elements in a video delivery infrastructure under highly scaled conditions, additional complementary metrics can be useful in some cases. These fall into two categories: subjective and objective measurements.

Subjective measurement relies on input from actual users watching a video after it has passed through the delivery network and decoder. Naturally, this method is the most accurate, since it polls users directly, rather than inferring their perception based on the properties of the video stream. ITU-T recommendation BT.500 proposes a methodology for conducting subjective evaluations. It is, of course, not practical to employ subjective measurement on a large scale, because of cost and time constraints. Furthermore, by its very nature, subjective measurement is not repeatable. Hence, it would be inappropriate to compare two pieces of network equipment characterized by subjective measurement. For this, we must turn to objective measurement.

Objective measurements are a category of metrics that infer video quality based on the video stream without direct input from users, although their models are often conditioned by user mean opinion scores (MOS). MDI is an objective measurement that relies on packet-level information. Many objective measurements look deeper and incorporate information about the codec's used in the media stream. MPQM, V-Factor (an MPQM implementation) and video-MOS model are examples of such techniques.

V-Factor, for example, considers the error concealment techniques included in certain encoding technologies and attempts to map the decoded video to perceived quality by accounting for the properties of human vision. Naturally, this operation is computationally complex and, for that reason, it is not feasible to monitor hundreds of video streams simultaneously using V-Factor without expensive hardware support. It is therefore impossible to ensure that all video streams passing through a device under test are delivering the proper QoE with this measurement. Furthermore, the MPQM algorithm used by V-Factor simply returns a number between 1 and 5 as an indication of video quality. While the results are on the same scale as the mean opinion score (MOS) reported in subjective testing, a single number on an arbitrary scale offers little insight into the cause of video quality problems. Finally, because MPQM and V-Factor consider the quality of the decoded video as a whole, impairments due to the encoding algorithm (e.g., low quality encoder/decoder, compression artifacts) are indistinguishable from impairments caused by the network devices actually being tested. Furthermore, "most artefacts that downgrade video quality come from the compression itself[1]," so metrics that consider compression and codec properties are of little use in assessing the effect of the network on video quality. Network devices can only switch, delay, or drop packets. Hence testing should only consider those actions' impact video quality. The limited scalability of MPQM, V-Factor and video-MOS also casts doubt on their usefulness in realistic network scenarios. Nevertheless these measurements do have valid applications: they are rather well suited to sampling the video quality observed by a single user, or the performance of a Set Top Box decoder.

	MDI	V-Factor, MPQM, Video-MOS, and other perceptual metrics
Highly scalable (measurements on hundreds of channels, thousands of subscribers)	Yes	No
Directly indicative of network problems relating to video quality	Yes	No
CODEC agnostic	Yes	No
Can be used with any encrypted media payloads	Yes	No
Results independent of encoding and decoding	Yes	No
Suitable for variable bit rate (VBR) video quality testing	Yes	Yes
Defined in an Internet draft	Yes	No
Correlated to user MOS scores	Yes	Yes
Suitable for real-time evaluation of video quality	Yes	Yes
Useful for establishing network margins	Yes	Yes
Support for MPEG-4 QoE analysis	Yes	No

1. Y. Coget, Measuring IPTV QoS performance at the box, Network Systems Designline, Online: http://www.networksystemsdesignline.com/howto/ipnetworking/180206240, Jan 11, 2006

Conclusion

As Triple Play deployments become a reality, it is imperative for service providers and network equipment manufacturers to test the devices that deliver IPTV and ensure that they provide the expected Quality of Experience. The most comprehensive and scalable way to do this is through use of the MDI measurement, which can monitor video quality simultaneously on a large number of streams. MDI also provides an indication of impending problems in the network and reports video quality results that facilitate problem isolation and root cause identification. Other metrics may be of use in testing encoders and Set Top Boxes, but MDI is the best way to test network equipment.

IPTV Test Solutions from Agilent Technologies

Agilent Technologies is the world's premier measurement company. Agilent delivers test solutions that provide rapid insight and accelerate time to market for its customers as they develop and deploy devices for Triple Play networks. Agilent's N2X platform of high-performance test systems provides a complete IPTV test solution, including highly scalable video generation and analysis capabilities. More information can be found on the web at www.agilent.com/comms/N2X, or by contacting your local Agilent salesperson or distributor.

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