Video Clarity

Tools for Video Analysis

Real Time Monitoring Explained

Executive Summary

Real Time Monitor (RTM) allows continuous quality measurements to be made during actual broadcasts for all types of video delivery systems, including broadcast, satellite, cable TV and Internet streaming. This technology provides a way to detect and measure many different kinds of errors that can affect video signals. The resulting measurements are compiled into a score that indicates how much video signal quality degradation would be noticed by a typical viewer who was watching the content.

RTM uses full reference methodology, which means that the equipment performing the test is supplied with two copies of the content: a source (or reference) version of the video content, and a version that has been processed through some type of network or equipment. This powerful technique allows measurements to be made in-service, so that normal video delivery can continue uninterrupted while tests are being performed.

Both RTM and traditional stimulus/response tests have a role to play in television broadcasting and distribution. (This explains why Video Clarity manufactures both types of test equipment.) RTM is particularly useful for continuous monitoring of real-time and live broadcasts, because it can use any type of video source. It is ideal for evaluating the impact on perceived video quality of the multiple encoder and multiplexer configuration choices that must be made in actual video delivery networks. Stimulus/response testing is more suited to evaluating and comparing specific system components in a laboratory setting. Stimulus/response works well for tasks such as comparing encoders from different suppliers, or detailed analysis of the impact of specific encoder enhancements against a known starting point.

RTM provides a number of benefits, including:

- A test of active systems without any impact or interruption to existing signals
- Works with all types of video content – no need for specialized test clips
- Can detect subtle equipment or network-based errors, such as loss of audio/video synchronization (lip sync)
- Offers long-term continuous monitoring, allowing random or infrequent events to be captured and flagged for later analysis

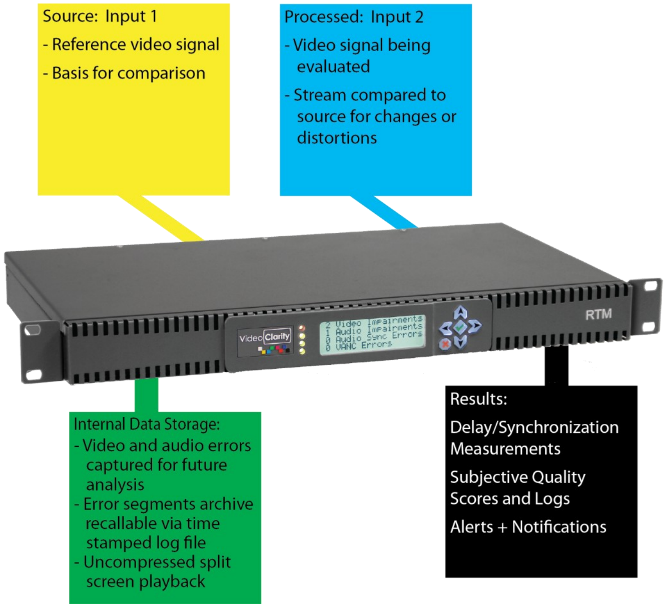
This paper will discuss how the RTM technique works in practice, and will show how it can be applied to various testing scenarios that are of interest to television program originators, broadcasters and distributors.

How RTM Works

The next step in the RTM process is an analysis of any differences between the two input streams. All types of differences can be measured, such as video compression artifacts with a PSNR metric, perceptual measurement of quality with a highly-accurate DMOS measurement, audio distortions, and changes in the vertical ancillary (VANC) space. Alerts can be created for significant changes in any of the key measured parameters including video quality, audio/video synchronization, and change in overall system delay.

System alerts can be put to a variety of uses. Messages can be displayed to alert the RTM system operator and time-stamped and logged for later problem review and diagnosis. Alerts can be sent to external equipment, including triggers used to control switching between primary and backup signal paths. Video clips that cause alerts are also be stored inside the RTM system for later analysis.

The RTM system produces a numeric score to indicate the quality of the received video image. The score is calculated using a mathematical formula based on the human visual perception system. A good score indicates that viewers will only notice low amounts of video degradation even though significant differences may have been detected between the input streams. This score can be used to assess whether a particular network or device is able to deliver a high-quality image.



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Video Compression Technology

Video today is essentially always digitized and compressed to allow it to be sent over transmission paths including: satellite, microwave, fiber, TV broadcast, and Internet.

MPEG and other video/audio compression standards have been widely implemented throughout the video industry. These standards describe interface specifications that define video, audio, transport, and timing requirements. Commonly used choices include MPEG-2 (DVD), H.263 (video surveillance), MPEG-4/H.264 (advanced video coding), JPEG (still pictures), JPEG-2000 (contribution and archival). All of these standards are typically implemented using *lossy* techniques, where information is lost during compression so the quality after encoding/decoding is not as good as the original.

In practice, all lossy encoders generate artifacts (areas of unfaithful visual/audible reproduction). If the encoder is designed well, adjusted properly, and if the data rate is high enough, then these artifacts will be virtually invisible to a human viewer. Encoder evaluation and parameter setting is frequently performed offline (in non-real-time with test video sequences) using a stimulus/response video quality analysis device like ClearView (www.videoclarity.com/products.html).

If a good encoder has been chosen and properly configured, then most of the errors that affect viewers will be due to:

- Real-time Compression
- Ad Insertion
- Statistical Multiplexing
- Re-encoding
- Transmission Systems

Each of these major error sources can be analyzed using RTM on real-time (and live) broadcasts, preventing any disruptions to viewers. The following sections discuss these error sources in greater detail.

Real-Time Compression

Real-time compression is needed for live transmissions (or retransmissions). The compression device (Encoder) runs making the best quality A/V streams possible. Two ways exist for encoding:

1. Constant Bit Rate (CBR)
2. Variable Bit Rate (VBR)

Encoders that use VBR (Variable Bit Rate) encoding produce more consistent video quality because they can change the bit rate of the compressed stream depending on scene complexity. Of course, more bits require more network bandwidth to stream. Many times, bandwidth allocations within the network are fixed, so VBR cannot be used.

Broadcasters usually implement CBR for fixed bandwidth applications – Internet delivery, Cable TV, Satellite TV, and IPTV. CBR is segmented into pieces, where the bit-rate over time is constant, but the instantaneous bit-rate is higher

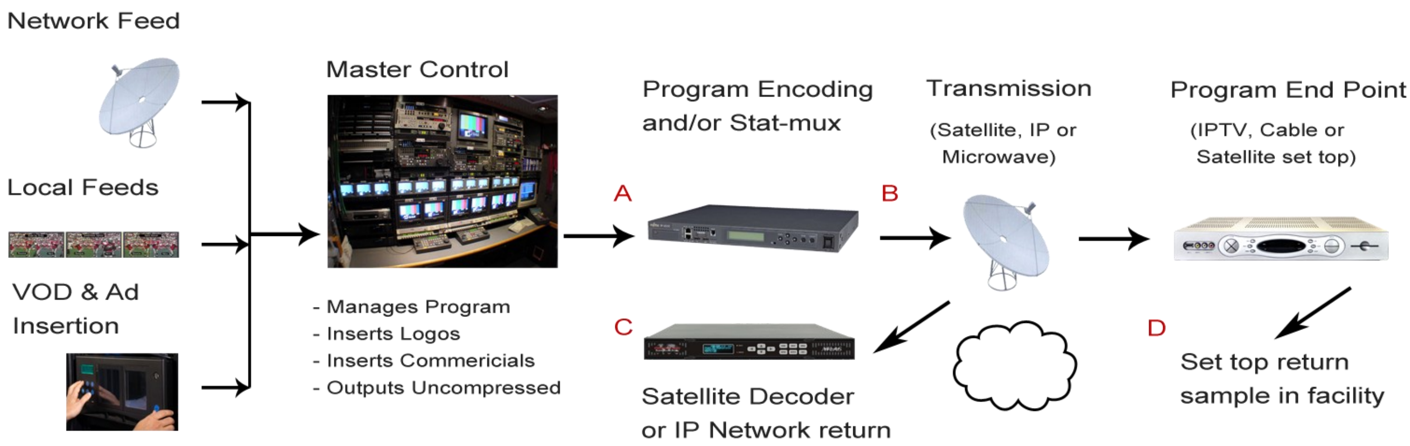

Figure 1 shows four locations labeled A, B, C and D where baseband signals can typically be accessed.

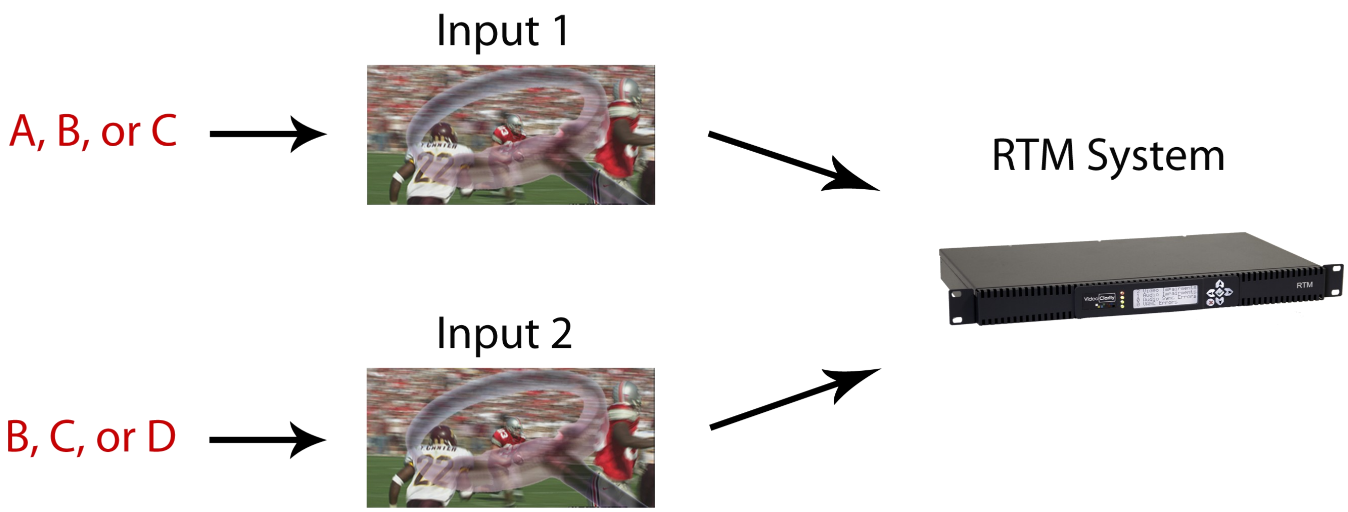

Figure 2 shows the relationship between source and processed signals that can be used as RTM inputs, using the A, B, C and D labels from Figure 1. Location A (master control output) is normally used only as a source signal and Location D (set top box output) is normally used only as a processed signal test point. Locations B and C can be used either as source or processed signals, depending on which segment of the overall path is being studied.

or lower depending on scene complexity. Buffers can be used to smooth out variations in bit rate caused by complex scenes.

Headroom is the amount of bandwidth in a CBR stream that has to be allocated to handle transient bit rate peaks in the video encoder's output. For real-time compression, it is very important to allocate headroom. When the headroom is not sufficient errors will occur because there will not be enough available bandwidth in the CBR stream. In this situation, some of the compressed video data will be lost, causing errors in the video image.

RTM can detect errors in the delivered video signal that are caused by bit-rate inconsistencies along the video signal distribution path. In particular, if the amount of headroom available in a CBR Stream is violated, the resulting video signal distortions will be captured, logged and recorded for later review.

Ad Insertion

Ad insertion is the process of inserting an advertising message into a stream. Ads can be inserted for a national broadcast, by local broadcasters, and by distribution providers such as CATV or DTH satellite providers. Special signals within the video stream (called cues) indicate the start and stop times for the inserted advertisements.

Problems can occur during ad insertion if:

1. Resolution or aspect ratio between the programming and advertising is different
2. Advertising starts or stops early or late
3. Advertising causes the real-time encoder to need more headroom

RTM can detect which portions of the video stream have been modified by inserting ads. This information can be further analyzed to determine if ad insertion equipment is working correctly. RTM can also measure program and advertisement loudness to conform to CALM with the latest standards based methods.

Statistical Multiplexing

Broadcasters frequently purchase a fixed amount of bandwidth from a telecom carrier or satellite operator. To maximize efficiency, they pack as many channels as possible into this bandwidth. The normal technique for doing this is called Statistical Multiplexing. Statistical Multiplexing is a technique for combining a number of uncorrelated, bursty traffic sources together so that the sum of their peak rates does not exceed the link capacity.

A series of encoders are arranged so that their output can be combined by the multiplexer (combiner) into a single multi-program transport stream (MPTS). Each encoder is given a target bit-rate and the multiplexer monitors the sum of the traffic. When an encoder encounters a complex scene, it requests more bits. The multiplexer takes unused bits from other encoders and allocates more to the requesting encoder. If too many of the encoders encounter a challenging scene concurrently, then problems will occur. The multiplexer will either deny the encoders request or discard data (drop frames). Either way, the video quality is affected.

Statistical multiplexing is important when delivering video over a fixed allocation – as in satellite, microwave, and fiber transmission. The subscribed data rate is guaranteed and the user would like to use as much of the entire bandwidth for which they subscribed/paid. Some statistical multiplexers use a look ahead technique, where the encoding is done in two phases. The first phase calculates the bit-rate and passes this information to the multiplexer ahead of time so that it can change the bit-rate before the oversubscription. RTM can identify video signal errors that are caused by improperly configured statistical multiplexers. This technique is particularly valuable for identifying problems that occur intermittently during live broadcasts.

Re-Encoding

Another approach which is similar to statistical multiplexing is known as re-encoding or rate adaptation. (This is not a full decode and encode – if a full decode is done, then it is better to use a statistical multiplexer.) Re-encoding modifies an existing compressed digital stream in real-time without decoding. When a re-broadcaster is pulling programming from multiple sources, combining them, and sending them over their fiber, satellite, IPTV, or microwave channel, they may choose to re-encode.

Re-encoding parses the compressed syntax and removes some of the video image details to fit multiple programs into a new MPTS. This is normally done in conjunction with a system multiplexer and when a new MPTS is groomed by pulling programs out of multiple MPTS source signals.

Once again, complex video scenes can cause a situation where the bandwidth becomes oversaturated, and thereby affect the video quality. RTM can detect these video degradations while the broadcast is underway, allowing for continuous monitoring and real-time network troubleshooting.

Transmission Systems

In transmission networks, video signals can either be transported over dedicated bandwidth (also known as guaranteed service) or over a shared network which may or may not have access control. When dedicated bandwidth circuits are used, errors are relatively infrequent, particularly in well-engineered fiber-optic networks. (Satellite circuits are much more vulnerable to interference and random noise errors, so they typically use advanced error correction technologies.) In shared networks, errors can be generated by transient peaks in data traffic that cause buffers to fill up and packets to be lost or discarded.

Regardless of the type of error, any loss of data in a video stream can cause defects in the decoded video image or audio sound. However, simply knowing that transmission errors have occurred does

not provide enough information to determine how much of an impact the error has on the delivered video and audio signals. The error could have been limited to a single frame of video, which could mean that it would never be noticed by most viewers. On the other hand, a single error could affect multiple frames or corrupted metadata could impact a whole segment of video if the metadata was corrupted. In addition, many decoders (particularly those in advanced set top boxes) do an excellent job of hiding errors from viewers by using techniques such as repeating video frames or requesting data retransmission.

RTM is an ideal technology for monitoring transmission systems, because it works on active video streams using the actual transmission networks that are being used to deliver signals. RTM measurements can be performed at any place where the baseband (uncompressed) video signal is available. If measurements need to be made at a place with only compressed video signals available, then a decoder can be used to recover the signal before it is fed into the RTM system.

Video Clarity RTM Solution

Real Time Monitoring (RTM) can be used at any point along a transmission path to compare two baseband (uncompressed) video streams. Any differences are noted and turned into a quantitative score indicating how much degradation has occurred from the reference (or source) to the downstre AV signal under test. The system provide alerts whenever an error causes visual, audio, and ancillary data glitches, reports if lip-sync problems occur, and saves the streams in the vicinity of errors. The goal of RTM is to provide all the information to choose plan of action for adjusting, modifying or

Conclusion

In summary, RTM provides the following functions:

- Receives and aligns two real-time (live) feeds
- Compares the two streams and provides a quantitative measurement of video and audio quality degradation
- Monitors the vertical ancillary space for any errors
- Calculates the amount of change in audio/video synchronization (Lip-sync)
- Saves portions of the videos stream adjacent to errors for off-line analysis

Monitoring throughout a distribution network can give a deeper understanding of the effect of errors at each stage along the overall path. Using Video Clarity's advanced RTM system allows real-time error detection, as well as error logging for deeper analysis immediately or at a later time. In the end, a well devised RTM system will cut costs, reduce customer churn, and provide a visually appealing product for viewers.