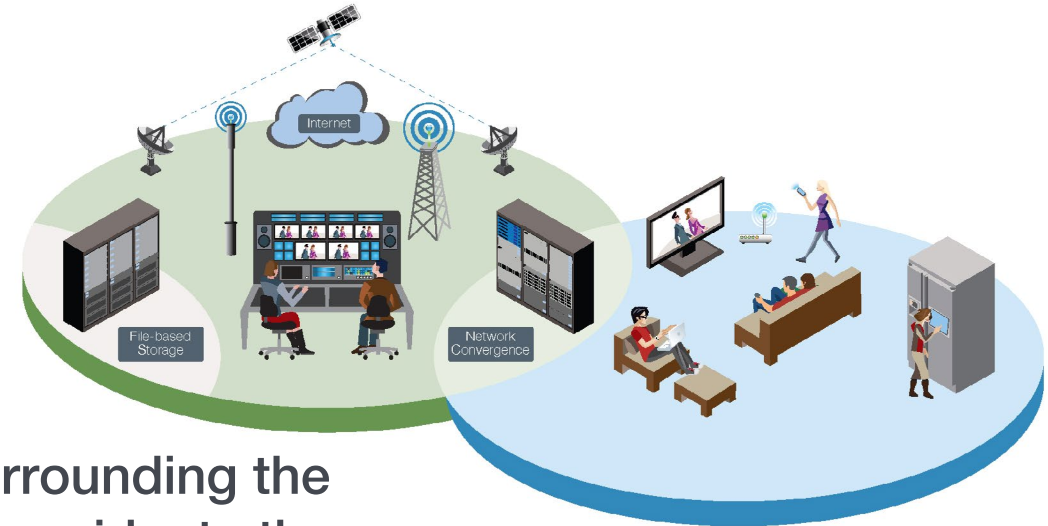
A GUIDE TO ENSURING QUALITY AND COMPLIANCE OF YOUR VIDEO AND AUDIO

Four Key Challenges of Delivering 4K/UHD

eBook

Tektronix®

Introduction



Exploring the process and issues surrounding the delivery of 4K/UHD from the service provider to the subscriber (i.e., TV, tablet, smart phone).

- 4K is defined as a television video format with 3840 x 2160 pixels (double the size of an HD format with 1920 x 1080 pixels)
- UHD is an acronym for ultra-high definition
- The Society of Motion Picture and Television Engineers (SMPTE) specifies UHDTV1 as the 4K format, and UHDTV2 as the 8K format (double 4K format)

With the momentum around 4K content and services continuing to build, a key focus for video service providers will be ensuring the quality of premium 4K content. One of the more demanding challenges will be implementing the new, more efficient High Efficiency Video Codec (HEVC or H.265) compression scheme while maintaining Quality of Service (QoS) and Quality of Experience (QoE).

QoS is defined as the quality of service of a program being delivered across a network. In this eBook, QoS is rated using RF and IP measurement results as well as the three DVB TR 101 290 priorities:

1) Necessary for decodability (basic monitoring)
2) Recommended for monitoring
3) Application dependent monitoring

QoE is defined as the quality of experience of a video program as seen and heard by a subscriber. QoE can be degraded through syntax and semantic errors which cause visual artifacts and audible clicks and pops.

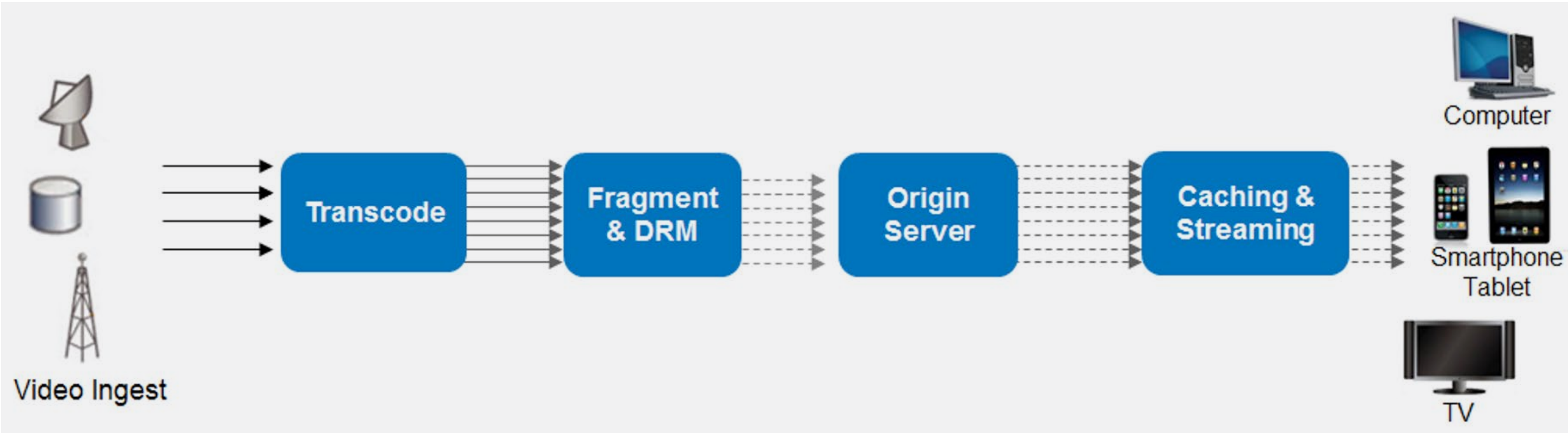


FIGURE 1. Typical example of an adaptive bitrate (ABR) architecture.

As 4K content is ingested from content creators, it is important to verify that this content meets specific requirements for format and quality. This is to ensure that the subscribers watching the program or TV channel get both the correct content and in the correct format. As acquired content continues to arrive from many different sources, verification should be applied to each source. Figure 1 above (left side) shows a variety of acquired content coming in from satellite, disk, and terrestrial sources. Each source requires validation of both the transport layer (RF or IP) as well as the content (e.g., Transport Stream, MXF, Video, Audio, Captioning/Subtitling, etc.). Testing the content of the source requires two types of tests: 1) syntax/semantics to ensure it will play, and 2) quality of video and audio to ensure customer experience.

Errors received on ingest could originate from a wide range of sources making it challenging to verify every possible type of potential problem. It could be as simple as the video format is in Standard Definition (SD) when it was expected to be in 4K or HD. Other more difficult issues include illegal parameters for a specific video codec (e.g., Out Of Range Motion Vector for HEVC). Many of these challenges will be covered in the following sections.

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CHALLENGE 1

VERIFICATION OF HIGH QUALITY SOURCE CONTENT

Fast and Reliable Automatic File-Based QC for 4K Content is Key

More and more content is being produced in 4K, but the content still needs to be delivered to video service providers at multiple resolutions, bit-rates, and in different codecs. In addition, these service providers may need to ingest and transcode many terabytes of files from many providers monthly. With limited time and resources, manual review is not an option. Automated quality control is an essential process before final playout.

Source Verification

4K content is most often delivered to service providers using Interoperable Master Format (IMF) files. This new format provides one very high quality video track (usually in JPEG2000), one or more audio tracks, and optional ancillary data. This allows the service provider to easily build an output file based upon associated Compilation Play List (CPL). The CPL file or files can be used to make a wide variety of output formats from MPEG-2 1080i in Spanish for Over-the-Air (no foul language) to HEVC 4K in both English and French for Cable TV (foul language OK). Figure 1.1 below shows the flow of 4K content from content providers to the subscribers over RF, VOD, or Over the Top (OTT).

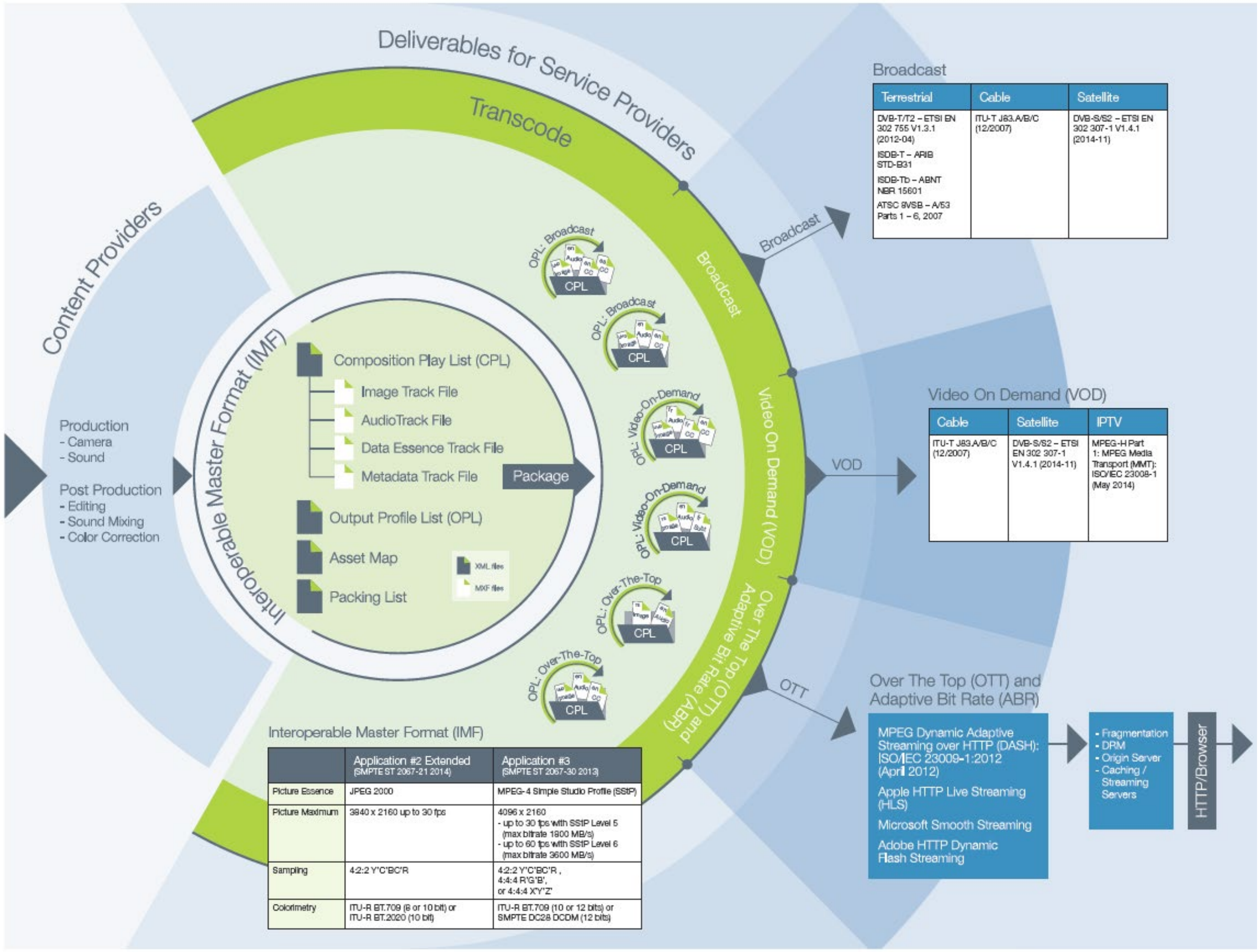

FIGURE 1-1. 4K content flow from content provider to subscribers.

To ensure interoperability between content providers, service providers, and subscribers (i.e., TV, Tablet, Smart Phone), it is critical that the agreed upon formats have no syntactic or semantic errors. A syntactic error occurs when a decoder receives an unknown command. All decoder commands are found within their respective approved documents. HEVC decoders use ITU-T H.265. An HEVC encoder does not need to use every HEVC command, but the ones that it does use must follow the approved standard from the H.265 standard.

Automated testing of files ingested from content providers can be efficiently performed by Aurora. Aurora, part of the Tektronix file-based validation suite, allows video service providers to perform fast and reliable automated quality assurance on file-based media from SD up to 4K resolution, with robust media asset management (MAM) integration support.

Aurora applies a defined template against the incoming file to determine compliance. This template should include requirements such as video codec compliance, aspect ratio, audio language, number of audio channels, etc. The larger the number of tested parameters, the higher the confidence level of the content being exactly what was expected. These template parameters can also include the maximum number of consecutive still or frozen frames, as well as compliance to audio loudness levels, plus many other video and audio baseband tests.

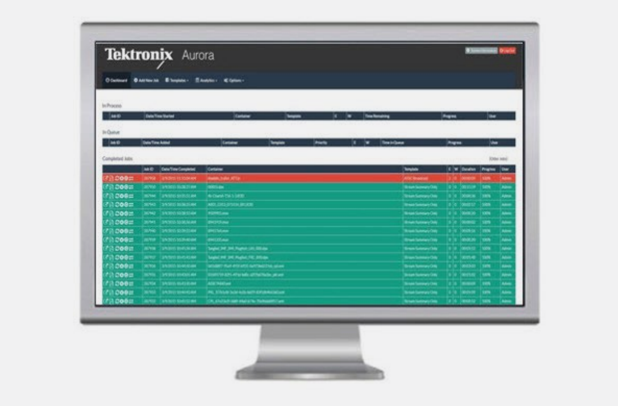

FIGURE 1-2. Tektronix Aurora Dashboard.

FIGURE 1-3. Tektronix Hydra application stepping through a log of compliance issues.

Figure 1.2 shows the Dashboard display of the Aurora application. The Dashboard lists each of the many jobs that have run, or are about to run. Each line includes a URL or link to the completed report, as well as to the Hydra application (see Figure 1.3) in case you want to view the actual video and audio frame or clip that is in error or at fault.

Aurora's companion, Hydra media player, offers frame-accurate manual review of 4K content to pinpoint quality problems easily and quickly.

The hope is that all ingested files will be error-free, but this does not always occur. Figure 1.4 shows an example of a DCT error (Discrete Cosine Transform) found within a file. The detected problem shows that the Intra-block DCT index is not below 64.

As noted before, compliance to the agreed upon standard is the key to maintaining interoperability. There is no rule or definition as to what should be done within a decoder when it runs into an error. Premium decoders may have enough built-in intelligence to mask, hide, or minimize some of the errors, while basic decoders simply fail or corrupt the video display. In the worst case, some decoders crash and require a power cycle. To prevent this problem, we need to catch syntax/sematic issues before they are delivered to the subscriber (e.g., TV, tablet, smart phone).

The following are examples of what the video could look like when a syntax error occurs. We will start with a clean short MPEG-2 video clip; then, for test purposes, use a hex editor to insert four strategically placed bit-errors into the first I-frame.

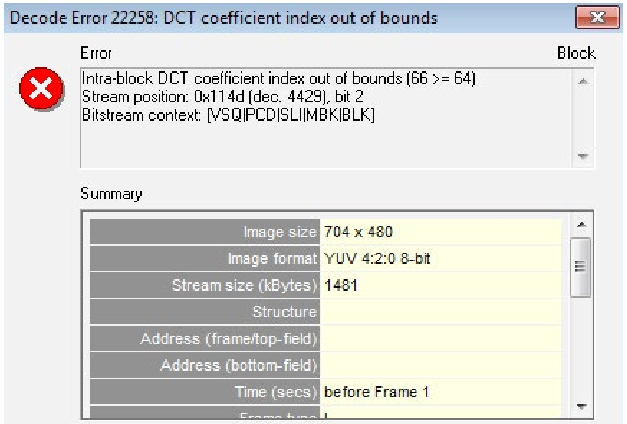

FIGURE 1.4. Bad MPEG video codec DCT index.

FIGURE 1.5. Anna without errors.

Figure 1.5 shows the first I-frame in the "Anna" clip. As shown, it is error free.

To illustrate this point, click here to view the above clean clip on YouTube.

FIGURE 1.6. Anna with four bit errors.

FIGURE 1.7. Anna with visual artifacts.

Figure 1.6 shows how impactful these four small bit-errors can be when they land inside an I-frame. Each bit-error inside the slice (i.e., 16 rows of pixels) causes a cascading effect until the end of that slice.

This effect is very bad in a compressed video element, but it can get even worse. Given that this is an I-frame, or anchor frame, it will be used as a reference for all of the B and P frames that follow. Therefore, the odd looking blocks, macroblocks, and slices, will be strategically moved around by encoded motion vectors until the next I-frame comes along. On average, this will linger for about 500 ms but will vary depending upon the length of the group of pictures (GOP). See this effect in Figure 1.7 after another 15 frames have passed.

To see how YouTube interprets this video clip, click here.

As noted earlier, every decoder will have a unique way of dealing with errors or unknowns. The video frames depicted in Figures 1.6 and 1.7 are from the rendering engines within VLC (VideoLAN.org decoder app) and the Tektronix MTS4EA reference decoder. As shown, syntax errors can have a large negative impact on the customer experience.

Solution

In a service providers' production flow, the following process by Aurora can be used on each and every file received from a content provider:

Actions taken by Aurora:

- Files that have errors are detected and rejected thus eliminating downstream interoperability issues. Aurora can send a report back to the content provider detailing the issues found.
- Files that are compliant are moved to another folder making them ready for CPL building and transcoding using the set of IMF files.

CHALLENGE 2

THE VERIFICATION OF TRANSCODING: COMPLIANCE, QUALITY, HEVC, AND OTHER CODECS/FORMATS

Industry giants are introducing Ultra HD premium content encoded with H.265/HEVC for linear broadcast and ABR delivery at multiple bit rates. Your customers expect superior picture quality, but how can you be sure that those streams all meet your quality targets? This challenge stresses the importance of real-time monitoring to ensure consistent picture quality and delivery.

Transcoding to HEVC

Transcoding from JPEG2000 or any of the many MPEG standards is another critical part to ensuring interoperability. As noted earlier, the HEVC standard (ITU-T H.265), is now the most efficient way to deliver 4K content to the subscriber. The HEVC standard includes many levels from level 6.2 for 4k (3840x2160) at 300 Hz down to level 1 for 128x96 at 15 Hz. Each of these levels defines a maximum bit rate and maximum luma sample rate. Figure 2.1 shows each of the many possible levels for an HEVC codec.

H.265 Video Frame Formats: Tiers and Levels with Maximum Property Values

Level	Max Luma Sample Rate (samples/s)	Max Luma Picture Size (samples)	Max Bit Rate for Main and Main 10 Profiles (kbit/s)		Example Picture Resolution Highest Frame Rate Maximum Decoded Picture Buffer (DPB) Size
			Main Tier	High Tier	
1	552,960	36,864	128	-	128x96@33.7 (6), 176x144@15.0 (6)
2	3,686,400	122,880	1,500	-	176x144@100.0 (16), 352x288@30.0 (6)
2.1	7,372,800	245,760	3,000	-	352x288@60.0 (12), 640x360@30.0 (6)
3	16,588,800	552,960	6,000	-	640x360@67.5 (12), 720x576@37.5 (8), 960x540@30.0 (6)
3.1	33,177,600	983,040	10,000	-	720x576@75.0 (12), 960x540@60.0 (8), 1280x720@33.7 (6)
4	66,846,720	2,228,224	12,000	30,000	1280x720@68.0 (12), 1920x1080@32.0 (6), 2048x1080@30.0 (6)
4.1	133,693,440	2,228,224	20,000	50,000	1280x720@136.0 (12), 1920x1080@64.0 (6), 2048x1080@60.0 (6)
5	267,386,880	8,912,896	25,000	100,000	1920x1080@128.0 (16), 3840x2160@32.0 (6), 4096x2160@30.0 (6)
5.1	534,773,760	8,912,896	40,000	160,000	1920x1080@256.0 (16), 3840x2160@64.0 (6), 4096x2160@60.0 (6)
5.2	1,069,547,520	8,912,896	60,000	240,000	1920x1080@300.0 (16), 3840x2160@128.0 (6), 4096x2160@120.0 (6)
6	1,069,547,520	35,651,584	60,000	240,000	3840x2160@128.0 (16)
6.1	2,139,095,040	35,651,584	120,000	480,000	3840x2160@256.0 (16)
6.2	4,278,190,080	35,651,584	240,000	800,000	3840x2160@300.0 (16)

FIGURE 2.1. HEVC Levels.

Feature Support in Some of the Video Profiles

Feature	Version 1		Version 2						
	Main	Main 10	Main 12	Main 4:2:2 10	Main 4:2:2 12	Main 4:4:4	Main 4:4:4 10	Main 4:4:4 12	Main 4:4:4 16
Bit Depth	8	8 to 10	8 to 12	8 to 10	8 to 12	8	8 to 10	8 to 12	8 to 16
Chroma Sampling Formats	4:2:0	4:2:0	4:2:0	4:2:0/4:2:2	4:2:0/4:2:2	4:2:0/4:2:2/4:4:4	4:2:0/4:2:2/4:4:4	4:2:0/4:2:2/4:4:4	4:2:0/4:2:2/4:4:4
4:0:0 (Monochrome)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High Precision Weighted Prediction	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chroma QP Offset List	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Cross-Component Prediction	No	No	No	No	No	Yes	Yes	Yes	Yes
Intra Smoothing Disabling	No	No	No	No	No	Yes	Yes	Yes	Yes
Persistant Rice Adaption	No	No	No	No	No	Yes	Yes	Yes	Yes
RDPCM Implicit/Explicit	No	No	No	No	No	Yes	Yes	Yes	Yes
Transform Skip Block Sizes Larger than 4x4	No	No	No	No	No	Yes	Yes	Yes	Yes
Transform Skip Context/Rotation	No	No	No	No	No	Yes	Yes	Yes	Yes
Extended Precision Processing	No	No	No	No	No	No	No	No	Yes

FIGURE 2.2. HEVC Profiles.

HEVC also define many different profiles. These profiles define a wide variety of video formats from the number of bits allowed for each pixel (e.g., 8 or 10-bits for Main 10), to the amount of chroma (from 4:2:0 to 4:4:4). Figure 2.2 shows the number of HEVC profiles for Version 1 and Version 2.

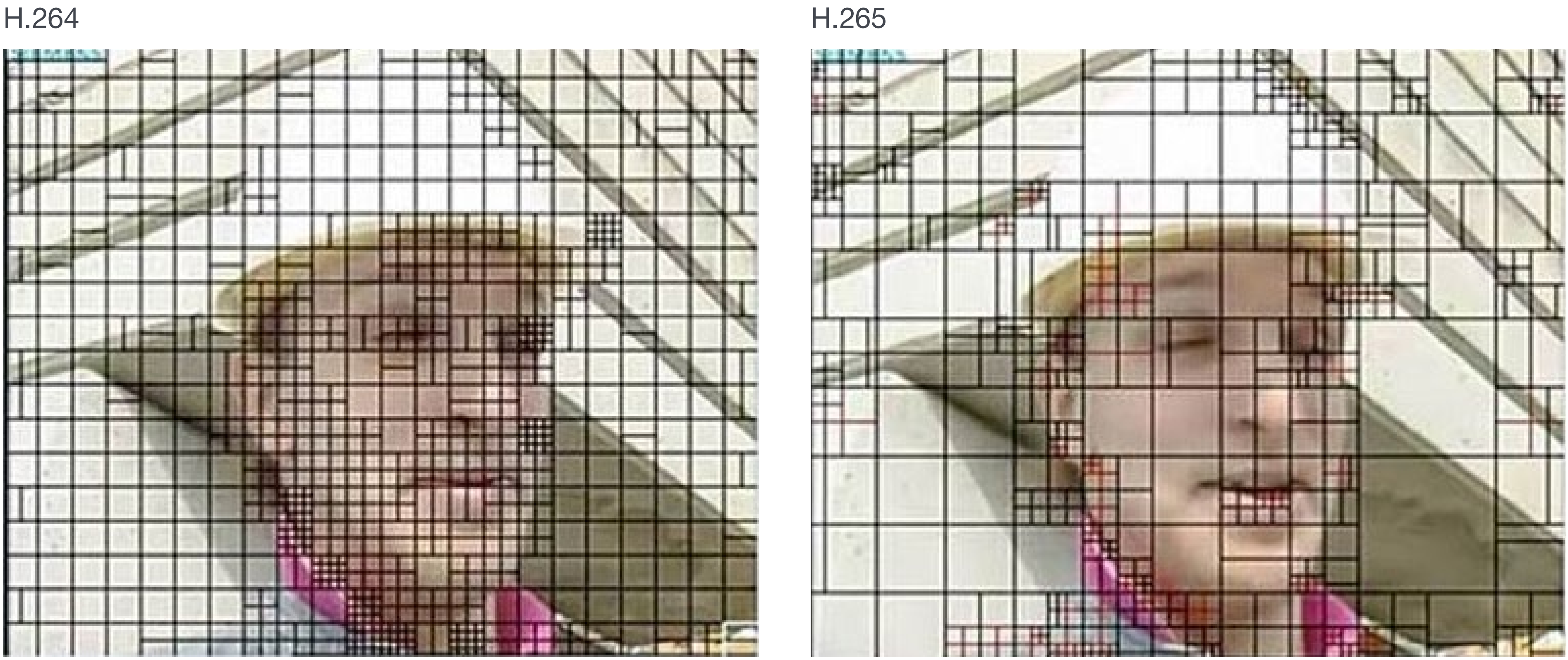

FIGURE 2.3. H.264 vs H.265.

HEVC is about twice as efficient as the ITU-T H.264 video codec standard, and one of the key bandwidth-saving features is its redefinition of blocks. Where MPEG-2 and H.264 used blocks, macroblocks, and slices, HEVC has eliminated all three of these in favor of new Coding Units (CU's). The largest size is the 64x64 coding unit. For pictures or video frames with large flat areas, this new feature allows for a large reduction in bandwidth. HEVC also includes more accurate motion vectors. The new 64x64 CU's probably make the biggest impact. Figure 2.3 shows the block and CU size difference on the Foreman video clip.

To ensure high QoS and QoE throughout the system, we need to test the ingested video program (MPEG-2, H.264, or H.265) and the output of the transcoded video. The Tektronix Sentry platform is a real-time monitor that monitors the physical layer, transport layer, and all the way down to the video and audio content layers. To advance the interoperability testing, Sentry monitors all layers for compliance, and can generate alerts, email messages, and SNMP traps. Figure 2.4 shows Sentry with video and audio QoE test measurements. The thumbnail is from a 4K HEVC stream over IP.

Sentry with HEVC QoE provides real-time monitoring of the output of encoders and transcoders down to the elementary stream level for block (Coding Units), including syntax/semantic errors that can result in blocky video and audio problems for the customer. Sentry can scale up to many channels simultaneously.

Sentry with Perceptual Video Quality (PVQ) checks HEVC streams for over-compression artifacts that can result in soft, washed-out pictures.

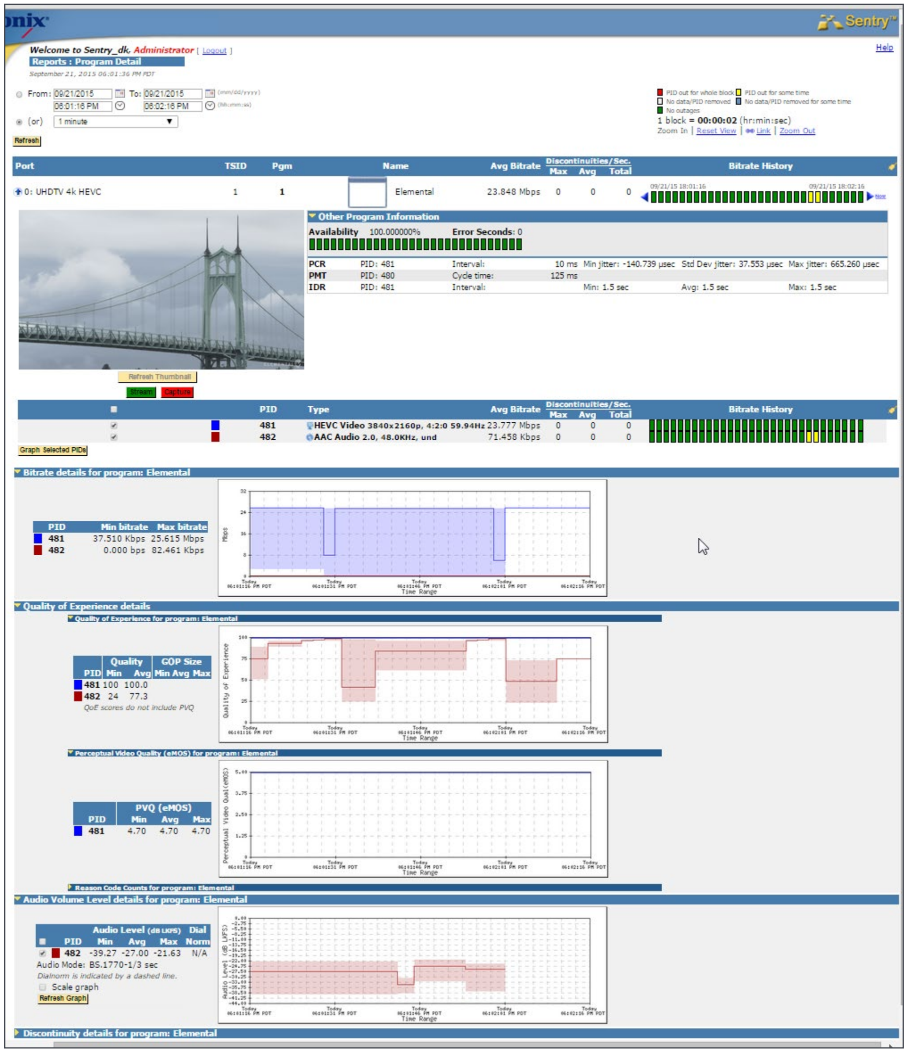

FIGURE 2.4. Sentry monitoring a 4K HEVC program.

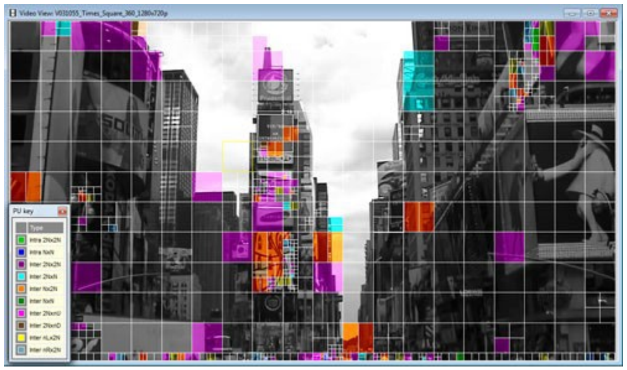

FIGURE 2.5. HEVC Coding Unit types.

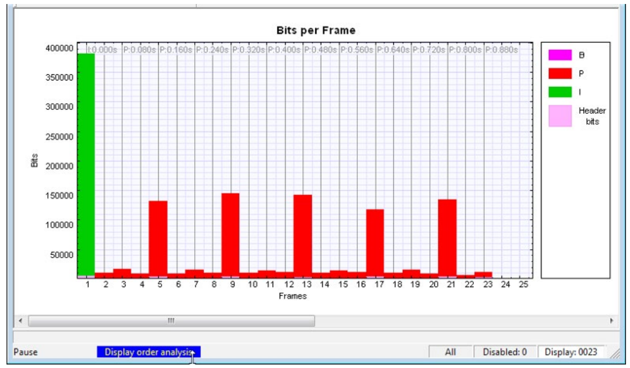

FIGURE 2.6. HEVC GOP structure and frame type/size.

Transcoded video is often used to scale or reduce bandwidth. In the case of OTT and ABR (discussed later), one video program will be transcoded into many video outputs. Each video will be at a different bit-rate, format, or both allowing remote clients to seamlessly switch between rates. This feature requires accurate timing alignment of the Instantaneous Decoder Refresh (IDR) and Encoder Boundary Point (EBP) frames. Sentry will monitor and alert any time that these alignment are outside the defined range.

Monitoring and troubleshooting often requires a deeper look into the compressed video or audio stream because of detected errors or QoS/QoE issues found by the provider or subscriber. In this case, the Sentry can be configured to automatically record a transport stream upon detection of such errors or issues.

The recorded transport stream file can be analyzed in greater detail by the Tektronix MTS4000, MTS4EA, or any other codec analysis tool.

Figure 2.5 and 2.6 show some of the MTS4EA codec displays that engineers use to debug HEVC elements when things go wrong.

Solution

At each point in the system where the stream is manipulated (e.g., transcoding, remultiplexing, etc.) it should be verified again. To assure interoperability, the Sentry product will monitor each of the output flows for bandwidth, audio levels, QoS, QoE, etc.

Actions to be taken:

If the Sentry tests show failure on QoE (syntax) or exceeded thresholds:

- The transcoder vendor should be contacted immediately to bring the equipment back into an interoperability state since delivering failed content to subscribers is bound to cause customer complaints.

If the Sentry tests show compliance:

- Stream or streams continue on to IP or RF modulation to subscribers.

CHALLENGE 3

DELIVERING 4K CONTENT TO THE HOME AND BEYOND USING IP AND RF: ENSURING COMPLIANCE AND AVOIDING CLIFFS

Is your RF and IP transport stream compliant and stable for delivery of your 4K content, or is it close to falling off the digital cliff?

Digital Video over RF

Now that we have completed the transcoding, we are ready to deliver the programming over RF or IP. For RF, the main formats are terrestrial, cable, and satellite. For each of these RF formats, it is important to maintain a high signal to noise ratio to ensure reliable delivery of the digital signal. As the signal level lowers or degrades, the noise become a greater part of the overall signal. At some point, this ratio approaches what we call the “digital cliff”. At this point, the built-in redundancy from forward error correction (FEC) and Reed/Solomon fails to preserve the compressed signal, and random values begin arriving within the decoder. This is where we begin to see tiling, slices errors, freeze frames, and then a complete loss of the program. With digital RF transmission, one of the signal to noise ratio tests is called Error Vector Magnitude (EVM) and is measured in percent. An EVM of zero means the received symbol landed directly center of the expected target location. An EVM of 100% is very bad and means that the received symbol landed outside the expected symbols’ target range, and usually in one of the other targets. The lower the EVM value, the better the signal quality. The higher the EVM value, the more that the receiver relies upon the Forward Error Correction (FEC) to correct any problematic symbols.

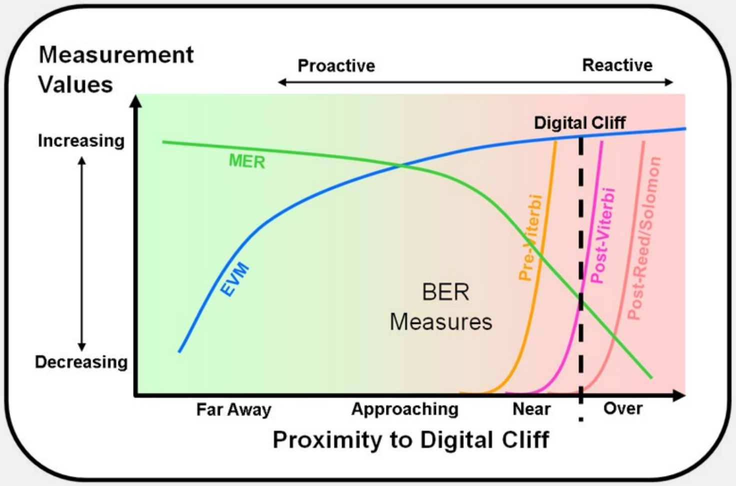

FIGURE 3.1. EVM/MER Vs Noise.

Figure 3.1 shows the inverse relationship between EVM and MER, and how an increase in noise or decrease in signal quality causes the signal to approach the “digital cliff”.

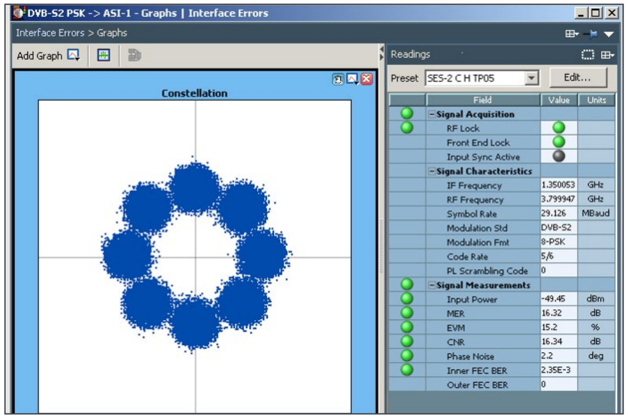

FIGURE 3.2. DVB-S2 8PSK Constellation.

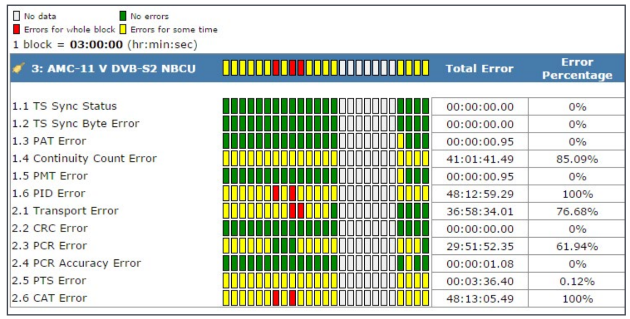

FIGURE 3.3. TR 101 290 report over 3 day period.

An example of a DVB-S2 8PSK signal is shown in Figure 3.2. The MER in this signal is 16 dB which is not great due to the significant amount of noise. The figure clearly shows that some of the received samples end up landing in unexpected target locations (symbol errors). This is also noted by the Inner FEC BER showing 2.35E-3. This means that about 2 bits out of every 1000 are wrong, so the Reed/Solomon FEC is required to correct these bad TS packets. As long as the rate stays better than 5E-3, we can declare this to be a quasi-error-free signal. Any worse, and some errors over time will leak into the video and audio element and become noticeable.

If you see poor FEC bit error ratio (BER), or if the TR 101 290 Transport Error Indicator (Priority 2.1) is red as in Figure 3.3, there is an RF transmission or reception problem. This could be due to rain fade, multipath, terrestrial interference, or any number of other RF impairments. Detecting the problem is step one. Eliminating the problem requires much more work. First, check your signal levels to ensure enough power. Second, ensure cable/coax integrity. For terrestrial interference (TI), a real-time spectrum analyzer will be required to pinpoint the exact location of the incoming TI.

Solution

Sentry monitoring of the RF signal to be delivered to the subscribers is required to ensure that the RF modulation, up-conversion, combiner, and amplifier are all running according to specification (e.g., levels, formats, etc.). The key tests here are RF power level, signal-to-noise ratio (MER), and ETSI EN TR 101 290 for transport stream compliance.

Actions to be taken:

- If Sentry detects a failure in all RF channels, the problem is most likely from the power-amplifier or possibly a bad coax cable.
- If Sentry detects a failure on a single RF channel, the problem is most likely due to a single failed modulator/up-convertor.
- If Sentry detects a TR 101 290 failure, it is most likely due to the multiplexer or the re-multiplexer built into the modulator. In this case, the multiplexer or modulator vendor should be contacted for resolution.

Digital Video Over Internet Protocol (IP)

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Delivering transport streams over IP with User Datagram Protocol (UDP) has almost completely replaced all previous forms of sending transports between equipment, buildings, and even around the country. Both the Sentry and MTS4000 have powerful IP monitoring features that allow for continuous monitoring of one or more UDP sessions, as well as the in-depth testing of video and audio elements, including HEVC. Monitoring local or distant UDP sessions can be beneficial when trying to pinpoint exactly where the IP error has been introduced. Standard browser IP traffic is lossless though Transmission Control Protocol (TCP/IP) where each packet is checked, and then resent if not 100% correct. In the case of video over TS, we use UDP which is more like "send and forget". If a packet becomes corrupt or lost, another copy is not sent. Therefore, it is very critical to ensure that 100% of the UDP traffic is maintained and error free.

What happens when you lose just one UDP packet over IP? It really depends upon a large number of parameters. For example, what type of codec is being used? How low is the bandwidth? Is the missing packet from part of an I-frame?

FIGURE 3.4. Sports without errors (All UDP and TS packets present).

To see this short error-free clip, click here for the YouTube link.

As we showed earlier in the corrupt Anna clip, the Sports clip below has a similar problem. In this case there are no bit errors, but there is a loss of one UDP packet which translates to seven TS packets. Since the loss happens to be within an I-frame, the impact is at its greatest.

The first clip is error-free (Figure 3.4), while the second clip is missing seven TS packets from the middle of the clip (Figure 3.5). As before, the resulting video display will be heavily impacted by the decoder itself. Some decoders will black out the bottom half of the bad frame, others will create a large number of oddly misplaced blocks, while others simply freeze the video until a new I-frame comes along.

FIGURE 3.5. Sports with one missing UDP packet (i.e., 7 TS packets).

To see how YouTube shows or hides these same errors, click here.

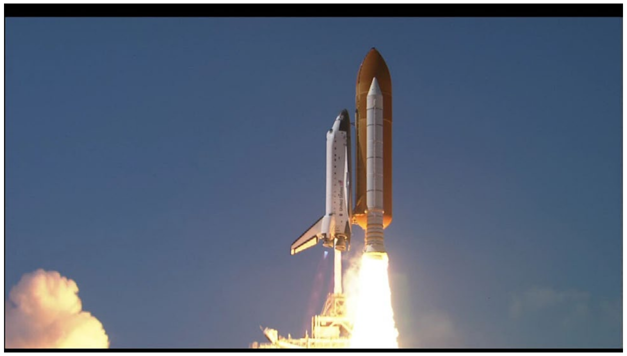


FIGURE 3.6. Space Shuttle without errors (All UDP and TS packets present).

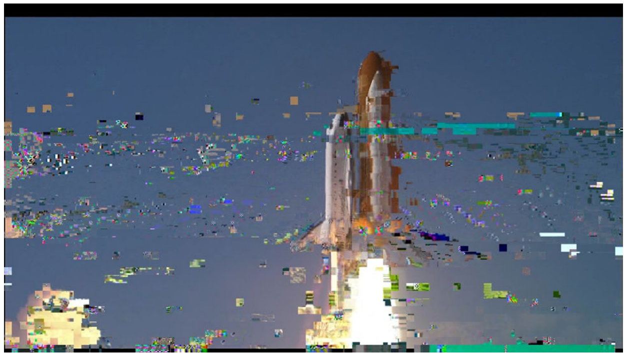


FIGURE 3.7. Space Shuttle with several missing UDP packets.

The previous example (Sports) was with a single UDP packet removed from the middle of a short IP stream. The following “Space Shuttle” example in Figures 3.6 and 3.7 is similar, but the IP errors are occurring at random, and also in a variety of I, B, and P frames. The resulting video is slightly different.

Solution

Sentry products test for IP problems such as Arrival Interval and Delay Factor. Sentry products also test for problems within the IP stream such as transport stream continuity counter (CC) and QoE, including codec syntax error checking.

Actions to be taken:

If the Sentry product shows failure of compliance in any of the above tests:

- The problem is most likely from a local IP switch or router failure (e.g., buffer overflow). A second Sentry could be used to pinpoint the source of the problem.

If Sentry tests show compliance:

- The IP sessions are delivered error-free over RF or IP to the subscribers.

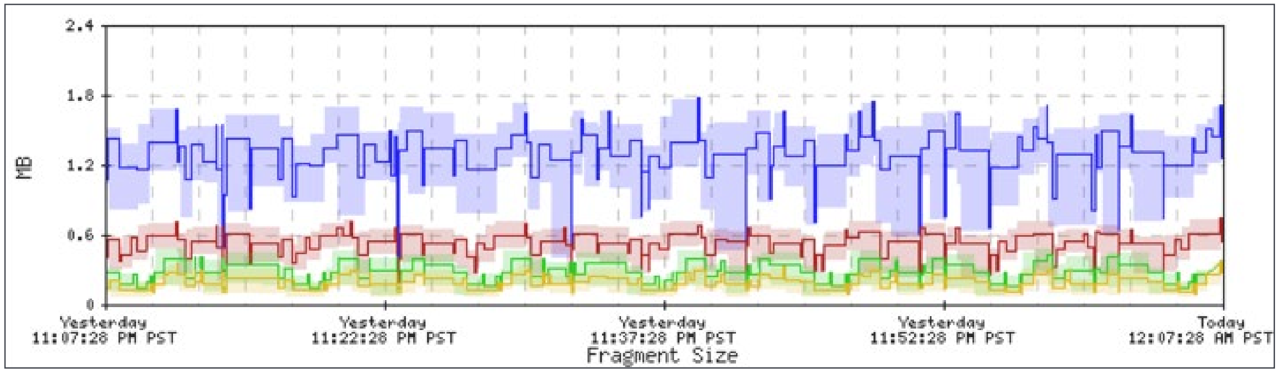


FIGURE 3.8. Sentry ABR Fragment sizes over one hour for all for profiles or representations.

ABR and OTT

With ABR and Over-The-Top (OTT) video, we have an entirely new method of delivering video to the subscriber. The key benefit with ABR is the ability to dynamically change the video bit rate (up or down) to prevent the "Buffering …" message displayed in the middle of a program.

ABR uses a completely different delivery method (TCP/IP) that includes retransmission of any missing or corrupt IP packets. The client-application (subscriber) communicates with the server to always maintain the highest possible bit rate. This requires the ABR solution to maintain several instances or video bit rates and formats (e.g., 4K, HD, SD, etc.), so that the subscriber does not need to guess which quality or profile will provide the best experience while having to stop and buffer incoming packets.

To monitor such ABR traffic, the Sentry ABR product provides a wide variety of TCP/IP QoS measurements and reports. This product will help to characterize adaptive bit rate (ABR) issues such as IP fragment headroom, load-time, latency, size, and bit rate. Figure 3.8 shows a Sentry ABR plot with fragment sizes over a one hour period. Providing a wide variety of ABR results over long periods of time will help any ABR/OTT engineer tune their network for optimum usage.

Solution

—

If the Sentry ABR detects a Fragment Load time that exceeds the Play-Duration time, the origin or caching server is not delivering all of the fragments in time to play. This could be due to the server being overwhelmed or redirecting the client to a distant caching server with a long latency.

Actions to be taken:

If the Sentry ABR product shows failure from the URL, HTTP, or Parsing alerts:

- The problem is most likely from the packager. Refer to the manifest file from the URL to determine the issue.

If the Sentry ABR product shows failure from the representation alerts (load time, latency, bandwidth mismatch, etc.):

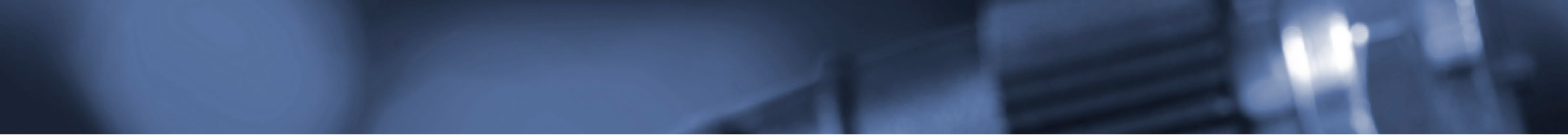
- The problem is most likely from the origin or caching server. Refer to the configuration of the origin server to determine the timing issue.

If Sentry tests show compliance:

- The IP sessions are ready to be delivered error-free over IP to the subscribers.

CHALLENGE 4

DEBUGGING IP



Problems with TS over IP can come from a variety of issues. Whenever an IP issue occurs, we need to pay close attention to the long and short gaps between UDP datagrams (i.e., jitter). When we see a long gap in time between packets, this could be due to a missing packet, or a switch latency issue. Both the Sentry and MTS4000 can show these long gaps between UDP packets. For additional IP testing, it is often necessary to record an IP flow to file (i.e., PCAP). With this recorded IP file, the MTS4000 can step through or debug each IP frame. Figure 4 shows the MTS4000 TSCA app looking for IP and TS issues within a recorded PCAP file. The benefit of using TSCA over other applications is its speed and interpretation of the data inside the PCAP file.

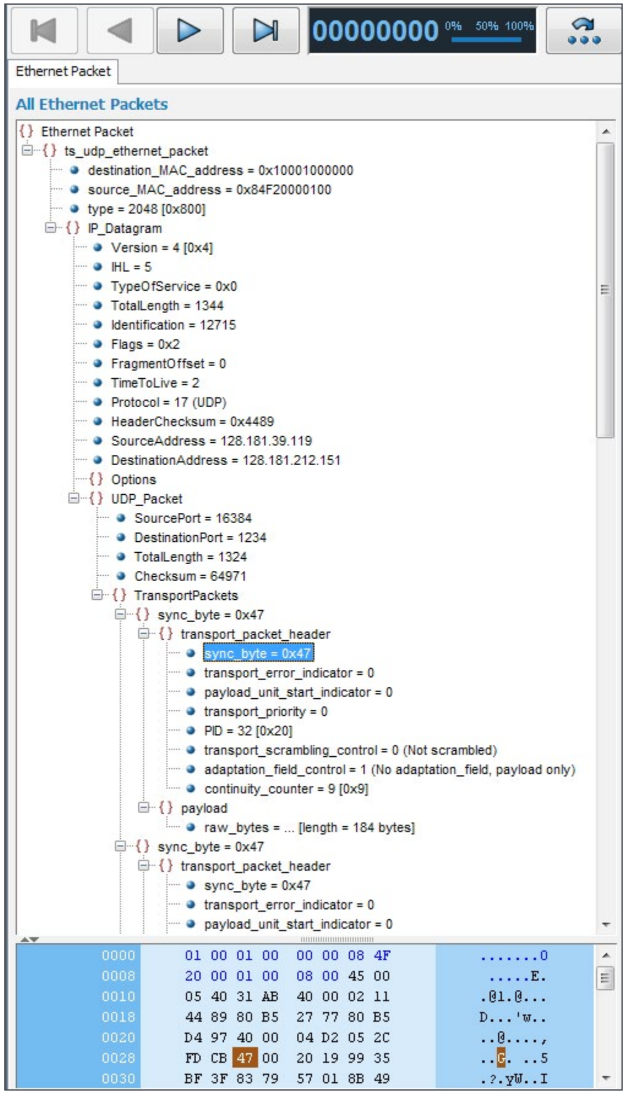


FIGURE 4. MTS4000 TSCA with PCAP and UDP display.

Solution

The MTS4000 is a multilayered transport stream analyzer that can test and monitor your 4K transport layer as well as the RF and IP layer for compliance, efficiency and stability. The MTS4000 also gives you the tools to easily determine the root cause of issues that will impact a customer's QoE.

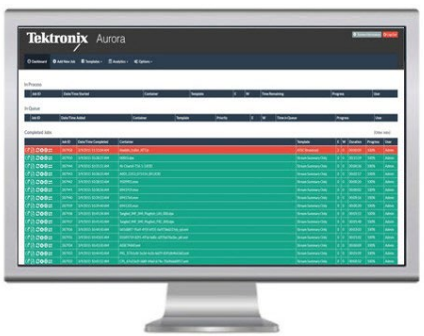
CONCLUSION

Validating video and compression formats along with high QoE are important parts of ensuring that the subscriber gets the right content from the service provider. Without interoperability (using agreed upon compression standards), some subscribers' decoders will generate poor video and audio (e.g., black, frozen, slice errors, audio silence, pops, etc.). The Aurora, Sentry, and MTS4000 products will help ensure compliance and quality.

In the 4K race, you can't afford to be left behind. The Tektronix Team has ensured a fast, smooth, and seamless transition from HD to 4K with minimal interruption to your workflow. We'll keep you on track to deliver an outstanding customer experience and quality content that meets regulatory compliance.

Tektronix Solutions

For measuring and monitoring compressed video content, Tektronix offers the Aurora application, Sentry platform, and MTS4000 Analyzer.



Aurora - Compliance within Files

A fully automated validation suite system for file-based content. This product identifies encoder compliance issues to prevent downstream receiver/decoder problems.

Sentry - Automatic Testing for Compliance within Networks

A scalable and comprehensive video network monitoring system that automatically detects and alerts QoS and QoE issues in the broadcast stream to quickly pinpoint failed equipment.

MTS4000 – In-depth Testing for Compliance within Networks

A diagnostic product that helps pinpoint interoperability issues between encoder, mux, and set top box equipment using a wide variety of RF, IP, and ASI inputs.

You're creating 4K/UHD Content. Together we can get it right the first time.

References

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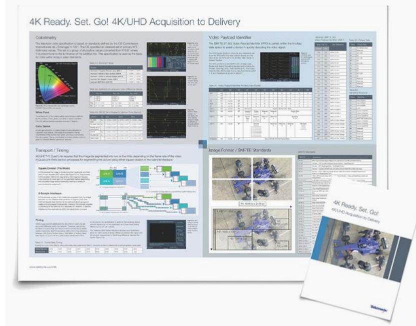
Complimentary poster explaining 4K acquisition

tek.com/4k



Complimentary poster explaining the delivery of 4K television using HEVC/H.265

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Acronyms

ABR	Adaptive Bit-Rate
ASI	Asynchronous Serial Interface
AVC	Advanced Video Codec (H.264)
B-Frame	Bi-directional picture Frame
BER	Bit Error Ratio
CC	Continuity Counter
CPL	Compilation Play List
CU	Coding Units
DCT	Discrete Cosine Transform
DVB	Digital Video Broadcast
EBP	Encoder Boundary Point
EVM	Error Vector Magnitude
FEC	Forward Error Correction
GOP	Group of Pictures
HD	High Definition
HEVC	High Efficiency Video Codec (H.265)

IDR	Instantaneous Decoder Refresh
I-Frame	Intra-coded picture Frame
IMF	Interoperable Master Format
IP	Internet Protocol
ITU-T	International Telecommunication Union - Telecommunications
LAN	Local Area Network
MAM	Media Asset Management
MER	Modulation Error Ratio
MPEG	Moving Picture Experts Group
P-Frame	Predicted picture Frame
PVQ	Perceptual Video Quality
PCAP	Packet Capture
OTT	Over-the-Top
QC	Quality Control
QoE	Quality of Experience

QoS	Quality of Service
RF	Radio Frequency
SD	Standard Definition
SNMP	Simple Network Management Protocol
TCP	Transmission Control Protocol
TI	Terrestrial Interference
TR	Technical Report
TS	Transport Stream
UDP	User Datagram Protocol
UHD	Ultra High Definition
UHDTV1	Ultra High Definition TV1
UHDTV2	Ultra High Definition TV2
VLC	VideoLAN Client
VOD	Video On Demand

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