ATSC BITSTREAM MONITORING

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ABSTRACT

The "correctness" of an ATSC DTV broadcast is critical to ensure that all viewers will be able to watch the broadcast content. An Ad Hoc group within ATSC (TSG-1, Bitstream Verification) was created to describe the elements of the appropriate standards (A/53 and A/65) that must be verified in an MPEG-2 Transport Stream for it to be considered a proper emission. This activity includes: enumerating the possible error conditions within an emission transport and establishing what's important vs. what's somewhat wrong (but may not have much impact). While all violations of the standards in an emission are incorrect, some might call for immediate response. Examples of the types of problems to be discussed include missing elements (which might result in inability to tune, missing programs or missing components of programs), table conflicts (which may confuse receivers and interrupt decoding) and timing problems (results ranging from inability to tune to slow tuning or updates of information).

INTRODUCTION

The only way to satisfy today's television viewers is to provide solutions which 'Just Plain Work.' When viewers encounter difficulties such as audio lip sync, blocking, or black screens, they turn to other channels. Viewer satisfaction suffers when customers find issues with transmission before engineers at the studio do.

Therefore, it is imperative that television engineers find and fix network, encoding, and transmission problems before their customers become aware of them. The length of time required to recover from a service-affecting problem can be broken into two parts:

Fault Detection Time (FDT) – The time between when the bitstream fault first occurs, and when engineers detect it.

Fault Isolation Time (FIT) – The time to identify the network equipment at fault, and correct the problem.

Total Service impairment time = FIT + FDT

Engineers strive to minimize the sum of FDT and FIT, thus minimizing the Total Service Impact. A bitstream monitor can drastically reduce both FDT and FIT.

NEED FOR BITSTREAM MONITORING

Many broadcast stations across the country use set top boxes and video monitors to confirm that they are 'on air.' With an analog signal this might have been sufficient; but digital broadcasting introduces another element to the monitoring equation - software.

Every digital set top box (STB) has software running on it. Depending on the implementation of the software in a specific STB, that receiver may react differently to a specific non-compliance in the bitstream. Problems that affect users of one type of STB, may not be visible to users of another brand of set top, or even a later model.

For example, one common error found in bitstreams is a conflict between the PSI information and PSIP information. Some models and makes of STBs are able to intelligently differentiate between correct information and wrong information and are fairly resilient to this kind of error. Viewers using this kind of box enjoy uninterrupted service. Other STBs may become confused, fail to display video at all, or even refuse to tune to the channel entirely. If the STB used to monitor the network is one of the former types, then the engineers at the studio are essentially blind. They don't see any problem in the stream at all.

Digital broadcast also carries non-video and audio data, such as the electronic program guide (EPG), closed captioning, and other program data [1,2,3]. Data-related problems are common, but it is very difficult to use a standard STB for monitoring these errors.

If the studio uses a bitstream analyzer to monitor their network, they will achieve a much shorter FDT. The monitor will identify stream non-compliance as soon as it happens, before any customers notice visual or audio aberrations. Many monitors can be configured to alert engineers when a problem first appears by sending e-mail, paging a phone number, or alerting an SNMP management system.

Bitstream monitors can decrease FIT as well as FDT. Two key problems exist when trying to map a video/audio aberration to a specific device or device setting. First: many different setup, configuration and software problems produce the same symptoms. Second a STB, typically limited with RF input only, provides insight to the broadcast signal at the end of its journey, but cannot easily provide insight to other points in the broadcast network.

Common examples of audio and video aberrations that can result from bitstream issues include video tiling, audio lip sync errors, and intermittent tuning. Without a monitor, it is not easy to identify the specific cause of a problem. For example, a given tuning issue may be due to dropped packets, or due to metadata errors in PSIP and MPEG tables. Without a monitor, the engineer's only tool is trial and error. Monitors help engineers find out where a problem originates in their network by tracing viewer problems to a specific deviation from the applicable standards.

Once the bitstream monitor identifies a problem in the stream, the monitor can be used to find out which device in the system introduced the fault. Monitors, unlike STBs, can be equipped with multiple input types. Engineers can monitor the RF using 8VSB, then examine the output of a MUX using SMPTE 310 or ASI.

Station engineers identify stream faults by stepping forwards or backwards through the network one device at a time, until the non-compliance no longer appears on the monitor. For example, if the monitor points to dropped packets in the 8VSB stream coming from the transmitter, dropped packets in the SMPTE 310 stream out of the MUX, but no problems at the output of a stream encoder, then the problem originates in the MUX. This systematic approach is not possible without a monitor, and can drastically reduce FIT.

THE SCOPE OF TSG-1

The greatest difficulty in using a transport stream monitor is interpreting the device's output. Does a specific transport stream error indicate a serious problem that requires immediate attention from station engineers, or has the monitor identified an error that is fairly benign?

The ATSC has recognized this problem, and an adhoc group within TSG (TSG-1) is in the process of addressing it. The output from this group will be a report that will discuss what needs to be monitored to ensure a compliant emission bitstream. Types of errors considered include (but are not limited to):

1. Transport stream errors
2. Elements missing from transport stream
3. Table conflicts
4. Timing problems

Using this report as a baseline, engineers can determine if their Monitor has detected a minor problem, or a potentially serious one that could bring their signal off the air.

ETR 101-290

ETR 101-290[4] is the standard used by DVB for transport stream error monitoring. It identifies transport stream error conditions, and classifies them by severity. ETR101-290 uses three priority levels:

Priority-one errors include those errors that affect the integrity of the transport stream and decodability of the MPEG-2 programs [5], such as sync errors, continuity counter error, missing PIDs, and PAT/PMT errors.

Priority-two errors are those that affect individual programs, such as PCR errors, table CRC errors and encryption related errors. ETR 101-290 recommends continuous or periodic monitoring of these errors.

Priority-three errors are application level errors related to individual elementary streams or DVB SI tables, such as audio and video buffer overflow/underflow errors.

ETR 101-290 provides a good framework for monitoring and classifying stream errors for DVB streams. It should be noted, however, that there are important differences between the ATSC and DVB digital television standards. A major difference in the bitstream level is the metadata: ATSC streams use PSIP for carrying tuning, EPG and other information, while DVB streams rely on PSI and SI tables for similar information. Although both ATSC and DVB streams are based on the MPEG-2 transport stream, ATSC and DVB standards have both placed additional (and different) constraints on a number of MPEG-2 parameters. Thus, ETR 101 290 cannot be directly applied to ATSC streams. A proposal to use the ETR 101 290 framework and extend its features for monitoring ATSC stream has been previously presented.[6]

TSG-1 APPROACH

TSG-1 has built upon the strong foundation of ETR 101-290, and adopted a similar approach that separates bitstream errors into different severity groups. However, the definition of the severity levels in the TSG-1 report and ETR101-290 is different. ETR 101-290 classifies errors in three categories. The TSG-1 report recommendations will use five, as described below. By increasing the granularity of error severity, TSG-1 hopes to avoid triggering false alarms. These are errors that appear in the stream, but are not service affecting. False alarms result in 'red lights' on monitors, which cannot always be cleared. These kinds of alarms 'train' engineers to ignore warnings from their monitoring systems. If engineers learn to ignore the warnings of their monitoring system then the utility of the monitor is greatly reduced.

The TSG-1 report identifies transport stream issues by type, dividing errors into the following categories: General, by PSI table (PAT and PMT), by PSIP table (MGT, VCT etc.), Timing Model, Buffering, and Consistency. Each error type is also provided with an error severity, from 1 to 5. See the table below for a definition of severity levels:

1	**TS failure**. The station is effectively off-air as the Transport Stream errors are severe enough that transport level logical constructs are damaged beyond utility. Receivers will not be able to tune and decode anything within the broadcast. The absence of sync bytes would be an example of this level of error.
2	**Program off air** A main service (virtual channel) is flawed to the point that that service is effectively off air for compliant/reasonable receiver designs. This could involve all of the program elements being improperly constructed or incorrect/missing signaling about elements. The absence of an entry in the VCT for a service would be an example of this type of error.
3	**Component missing**. One or the program components that is signaled by PSIP or the PMT as present is either not present or cannot be found and decoded. One example would be a mismatch between the video PID signaled in the SLD and the actual PID used for the video elementary stream.
4	**Quality of Service (QOS) error**: Parameters are out of specification bv such a margin that a significant fraction of the receivers can be expected to produce flawed outputs. In many cases, the broadcast is viewable, but may exhibit some form of degradation to the viewer. An example might be the MGT cycle time being somewhat larger than the specification, which would cause slower than normal tuning.
5	**Minor Non-Compliance**: Violates the letter of the standard, but in practice will have little effect on the viewing experience. Errors of this type should be corrected, but do not have the urgency of higher severity errors. An example might be a single instance of a 152ms MGT cycle time (with the remainder of the MGTs coming at less than 150ms intervals).

The TSG-1's work on determining the error levels of various transport stream errors is still in progress. The following shows a preliminary list of error types belonging to each category. It should be noted that these are incomplete and may subject to further change. It should also be noted that there are levels within the error types listed below that result in a different categorization.

Level 1 – TS failure includes sync loss error, cadence sync byte error (ex. No sync byte found in a number of bytes), missing PAT or PAT syntax error, missing MGT or MGT syntax error, missing TVCT or syntax error.

Level 2 – Program off air includes missing PMT or PMT syntax error, missing EIT-0, missing PCR or incorrect PCR values, or missing program elements in TVCT which may be detected as an inconsistent error between TVCT and PAT/PMTs.

Level 3 – Component missing includes missing Video or Audio Program Elements, missing EIT or EIT syntax error, ETT, STT and RRT error, or PTS error.

Level 4 – Quality of service (QoS) includes table repetition interval error, PCR interval or jitter error, PTS interval error.

Level 5 – Minor non-compliance includes all the errors that violate the standards, but not included in all the above four categories.

DIFFICULT ISSUES UNDER CONSIDERATION BY TSG-1

In order to intelligently associate errors with severities it was sometimes necessary to confront issues that were not well defined in any standard (or essentially out of scope). For example, the ATSC defines minimum table repetition rates for each mandatory PSIP table. MPEG defines PSI minimum table repetition rates. Minor violations of table repetition rates violate these standards, but are not likely to cause serious decode problems. However, if the PSIP/PSI tables go 'missing' from the stream all together then most set top boxes will not be able to tune. The key question is how to differentiate 'broken interval' from 'missing altogether'. While the ATSC standards do define when a table interval is out of specification, it does not provide a guideline for how long to wait for a table before it should be considered 'gone from the stream.'

Another commonly reported problem is conflict between the PAT/PMT and PSIP. If the information contained within these tables (and their associated descriptors), do not match, then tuning and decoding may be compromised. For example, if the Service Location Descriptor in the VCT does not match the information in the PAT/PMT, then some set tops may not be able to find the signal, while others may operate with no difficulties. TSG-1 sought to provide guidelines on which conflicts are severe, and which ones are likely to cause outages.

CONCLUSION

The work of TSG-1 is intended to create a test guideline for monitoring ATSC bitstream conformance. The guideline will provide a list of parameters to be tested and define the severity of different error types. It will also provide an efficient tool for broadcasters to monitor whether their streams are compliant to ATSC standards and allow troubleshooting of any problems that may occur.

TSG-1 provides a common methodology for describing bitstream non-compliance. In the future, studio engineers, technical support, and system integrators will classify existing problems in similar terms. A common methodology removes the obstacles to communication, and significantly reduces the time required to address system configuration and software faults.

REFERENCE:

1. ATSC Standard: Program and system information protocol for terrestrial broadcast and cable (Revision B) A/65B
2. EIA Standard: Digital television (DTV) closed captioning EIA-708-B.
3. ATSC Standard: ATSC data broadcast standard A/90
4. ETSI TR 101 290 v1.2.1 (2001-05) Digital Video Broadcasting (DVB) Measurement guidelines for DVB systems.
5. ISO/IEC 13818-1 Information technology – Generic coding of moving pictures and associated audio information: Systems
6. J. Shen and D. Bhat, Monitoring Priority of ATSC DTV Stream Parameters, Broadcast Engineering Conference, 2005.