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**Recommended Practice for Monitoring Multimedia
Distribution Quality**

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1. Scope

This document is identical to SCTE 168-6 2010 except for informative components which may have been updated such as the title page, NOTICE text, headers and footers. No normative changes have been made to this document.

The scope of this **Recommended Practice** document is to provide background and discussion on Multimedia Management (MMM) system requirements to assist the cable operator with MMM deployment design tradeoffs as well as provide guidance and recommendations on several topics related to the deployment of Multimedia Management systems based on the experiences to date of both the participating committee operators and vendor companies and the directions of ongoing work in the HMS. The topics include:

- Integrated and Independent Monitoring Strategies
- Recommendations for Quality and Service Assurance Data Acquisition
- Recommendations for Quality and Service Assurance Visualization, Reporting, and Export
- MMM System Security Considerations

This background and set of recommendations is intended to provide guidance to operators who are planning to deploy or are currently deploying MMM systems. This information is intended to be used with that provided in other HMS MMM documents.

2. Informative References

RFC 0768 User Datagram Protocol
RFC 0791 Internet Protocol
RFC 792 Internet Control Message Protocol (ICMP)
RFC 826 Ethernet Address Resolution Protocol
RFC 1112 Host extensions for IP multicasting
RFC 1349 Type of Service in the Internet Protocol
RFC 2236 Internet Group Management Protocol, Version 2
RFC 3376 Internet Group Management Protocol, Version 3
RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers
RFC 3357 One-way Loss Pattern Sample Metrics
RFC 4445 A Proposed Media Delivery Index (MDI)

ISO:

ISO/IEC 13818-1 Information technology – Generic coding of moving pictures and associated audio information: Systems (MPEG 2 Transport Streams)

CENELEC:

EN 50083-9 Cabled distribution systems for television, sound and interactive multimedia signals Part 9: Interfaces for CATV/SMATV headends and similar professional equipment for DVB/MPEG-2 transport streams (DVB ASI)

ITU:

ITU-T J.83 Series J: Transmission of Television, Sound Programme and other Multimedia Signals, Digital transmission of television signals (64-QAM, 256-QAM, 8-VSB)

ITU-T Y.1541 Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks, Internet protocol aspects – Quality of service and network performance (06/2006)

SCTE:

SCTE 35 2007 Digital Program Insertion Cueing Message for Cable

SCTE 142 2009 Recommended Practice for Transport Stream Verification

SMPTE:

SMPTE 2022-1-2007 Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks

SMPTE 2022-2-2007 Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks

DSL Forum:

Technical Report TR-126: Triple-play Services Quality of Experience (QoE) Requirements

IEEE:

IEEE 802.1Q -2005, IEEE Standard for Local and metropolitan area networks, Virtual Bridged Local Area Networks

3. Compliance notation

“SHOULD”	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
“SHOULD NOT”	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
“MAY”	This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

4. Definitions and Acronyms

8-VSB – Acronym for 8-Level Vestigial Sideband (Digital TV RF modulation format)

DPI - Acronym for Digital Program Insertion

DTV - Acronym for Digital Television

MMM – Acronym for Multimedia Management

Mux – Multiplexer

PAT - Acronym for Program Association Table

PCR - Acronym for Program Clock Reference

PES - Acronym for Packetized Elementary Streams

PID - Acronym for Packet ID

PMT - Acronym for Program Map Table

PSI - Acronym for Program Specific Information

PTS - Acronym for Presentation Time-Stamp

QAM - Acronym for Quadrature Amplitude Modulation

QoS - Acronym for Quality of Service

RF - Acronym for Radio Frequency

SCTE - Acronym for Society of Cable Telecommunications Engineers

SI - Acronym for Service Information

TS - Acronym for Transport Stream

5. Introduction

5.1. The Evolving Requirements for End to End Multimedia Management

Operators face an increasingly competitive multimedia distribution landscape which increases the demands for operations efficiency. Successful, cost-effective, and reliable high quality delivery of thousands of media streams through dozens of network processing equipment nodes in a delivery network to hundreds of thousands to millions of subscribers requires an automated quality assurance system. The quality assurance system must correlate per-program impairment events throughout the network to provide an intelligent view of performance data to operations personnel in order to minimize maintenance expenses in detecting, locating, and repairing faults. Today's modern dynamic and growing physical IP plant deployments along with a growing subscriber base demands this to maintain an operator's competitiveness. For most deployed multimedia systems designs relying on highly compressed video streams such as MPEG 2 or MPEG 4 AVC, even a *single uncorrected IP packet loss* on a viewed stream likely results in a customer perceivable impairment.

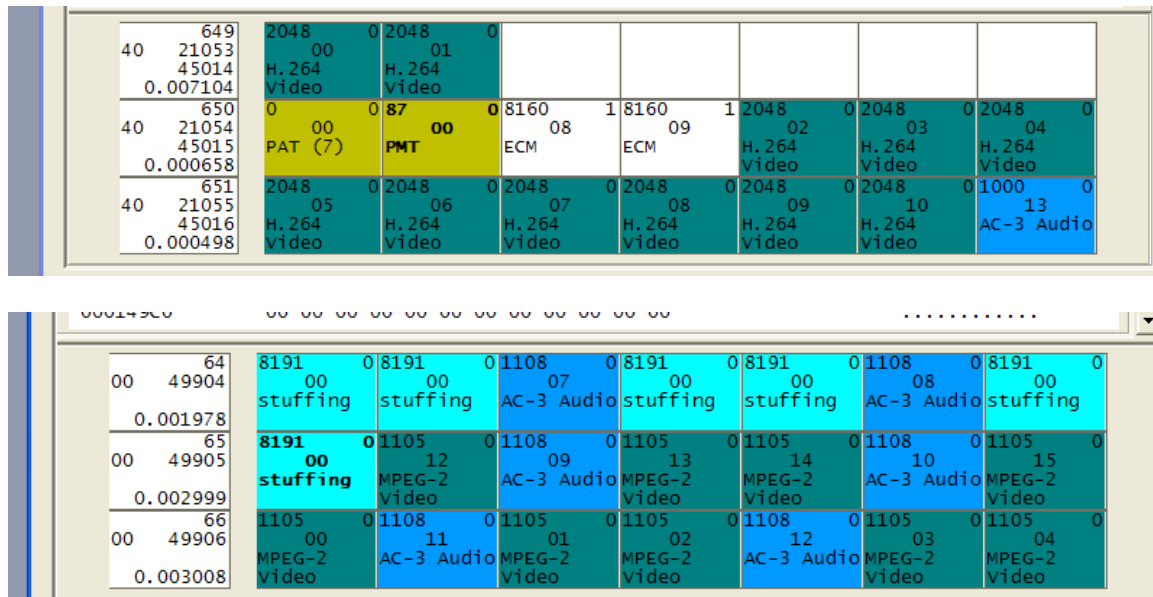
RECOMMENDATION-1. An effective operational Quality Assurance system that continuously monitors all distributed PIDs is recommended for an operator's modern high volume media over IP network.

Stream processing devices as shown in HMS 159 are often supplied with management tools that describe the health and diagnostic results of that element. For example, the parameters described in the HMS 154 encoder MIB (& other HMS MIB examples) shows how a device is configured for stream bit rate, compression algorithm type, coding delay, enabled/disabled status, PID assignments, Port and Protocol status, Up/Down input stream status, input clock sync, input/output amplitude levels. However, per-PID compliance monitoring employing information such as described by SCTE 142 Transport Stream Verification and flow monitoring such as described in RFC 4445 is not usually included – that is, it has been too costly and complex for every processor device to incorporate per PID analysis (Transport Stream Verification) for all PIDS processed.

Yet, to keep costs in check, an operator must know immediately ***if*** transient PID issues occur, must know ***where*** they occur, and must have network visualization tools that allow ***correlating*** issues for fault isolation and for cost effective troubleshooting dispatch. Without such tools, the operations staff is reduced to best guesses, random interconnect and device replacement, switch/router configuration and tuning with no way to measure results. Quick problem resolution and root cause analysis using these measurement and analysis methods allows the operator to improve customer satisfaction and reduce churn.

Multimedia over IP Considerations – For most deployed systems to date

Most deployed digital media systems to date by operators have employed media over IP networks for major portions of the infrastructure and use ISO 13818-1 MPEG Transport Streams over UDP/IP, with Ethernet protocols. An example of MPEG over UDP/IP protocol analysis is shown in Figure 1 below.



popular protocols prevent the network from handling one type of information differently from another since each type of information can be mixed within the same IP packet.

With every packet loss carrying the likelihood for audio and/or video corruption, it is obvious and critical that an operator be able to detect all packet losses on all flows throughout the network and be able to determine when and where such losses occur for quality assessment and fault isolation maintenance. An acceptable IP packet loss magnitude and frequency can be directly related then to how often and how severe subscriber impacts are expected to be tolerated. Some reasonable assessments have recently been published by the DSL Forum in TR-126 based partially on previous work by CableLabs (*see section 4.3 for more details on setting acceptable metric thresholds for the cable environment*):

Compression Type	Resolution (bitrate)	Max Error Frequency	Max # IP Packets Per single Error
MPEG 2	SD	1 per Hour	7 IP packets
MPEG 2	HD	1 per 4 Hours	27 IP packets
MPEG 4 AVC/VC1	SD	1 per Hour	5 IP packets
MPEG 4 AVC/VC1	HD	1 per 4 Hours	17 IP packets

DSL Forum Recommended Minimum Transport Layer Performance Parameters for Satisfactory QoE for MPEG-2/MPEG-4 encoded SD/HD TV Services (TR-126)

With the growing features and complexity of provider network delivery systems that now include VoD, simulcast, Digital Program Insertion (DPI), Switched Digital Video (SDV), along with VoIP and High Speed Data (HSD), maintaining these quality standards is nearly impossible without a continuous improvement feedback system. One method available is a system that continuously measures per-PID quality as determined by selected metrics and can provide trend information to confirm that investments and improvements are yielding the expected results. When impairments do occur, such a system of measurements available across the transport network is needed to be able to locate the source of impairments for corrective action quickly and accurately.

Multimedia over IP Considerations – For some emerging technologies

There is a growing consideration in Digital Video networks to include Forward Error Correction (FEC) and/or ARQ protocols in network segments carrying video to improve the effective packet error rates. Both these methodologies use additional network bandwidth to correct for packet loss either by reconstructing the missing packet(s) from a repair stream (FEC) or through retransmission of the missing packet(s) upon demand from a receiver (ARQ). These mechanisms may change the recommended target values mentioned above. These mechanisms are not currently common in cable operator networks. Both mechanisms also introduce additional latency in program delivery times.

5.2. Metrics for Quality of Service and MMM Technical Feasibility

Experience over several years of operating plants with digital streaming media over IP networks has shown that many types of faults are transient in nature and difficult to localize and troubleshoot with traditional techniques. Today's methodologies include, for instance, a technician directly viewing and listening to one or more programs or using one-time measurement tools and video monitors. This document, on the other hand, identifies monitoring practices that **automatically** examine program flows **continuously** and at multiple locations in the transport network simultaneously to facilitate the identification and location of both transient and persistent impairments. Through the judicious selection and use of optimal metrics at optimal locations, cost and complexity of this approach is kept reasonable and makes this approach feasible.

RECOMMENDATION-2. To provide a cost effective solution for Multimedia Management and monitoring it is recommended that continuous program monitoring at multiple simultaneous strategic locations be deployed to make possible traditional “divide and conquer” troubleshooting for transient streaming media impairments.

- For example, if a program is continuously monitored at the Head End (metro, regional, or national), within the IP transport network, and at a Hub site as it enters the HFC network, any transient impairment can be detected whenever and wherever it occurs.
- By examining the timestamps of logged impairments at each of the monitoring locations, it is possible to determine the most upstream location of the impairment -- the impairment origin -- for purposes of assigning the correct technical resources to the correct location for detailed troubleshooting.
- The resolution, or ability of this approach to locate a particular fault location, depends on how many distribution system demarcations are simultaneously monitored. While more locations will expedite locating a fault, this will require more capital investment.

This document makes recommendations on key demarcations that ***should*** be continuously monitored to locate a fault to a building location and includes ***minimum recommendations*** for configurations and systems where capital investment is particularly constrained.

Figure 2 illustrates a simplified end-to-end monitoring system with demarcation examples at the Head End, IP Transport cloud, Hub Site, and HFC network. The vertical bars indicate stream monitoring locations while the dotted vertical lines show Head End, IP core, and Hub site demarcations. By continuously monitoring each program simultaneously at multiple downstream locations, an impairment can quickly be detected and its location determined. By selecting the appropriate metrics at each location, cost and complexity can be minimized.

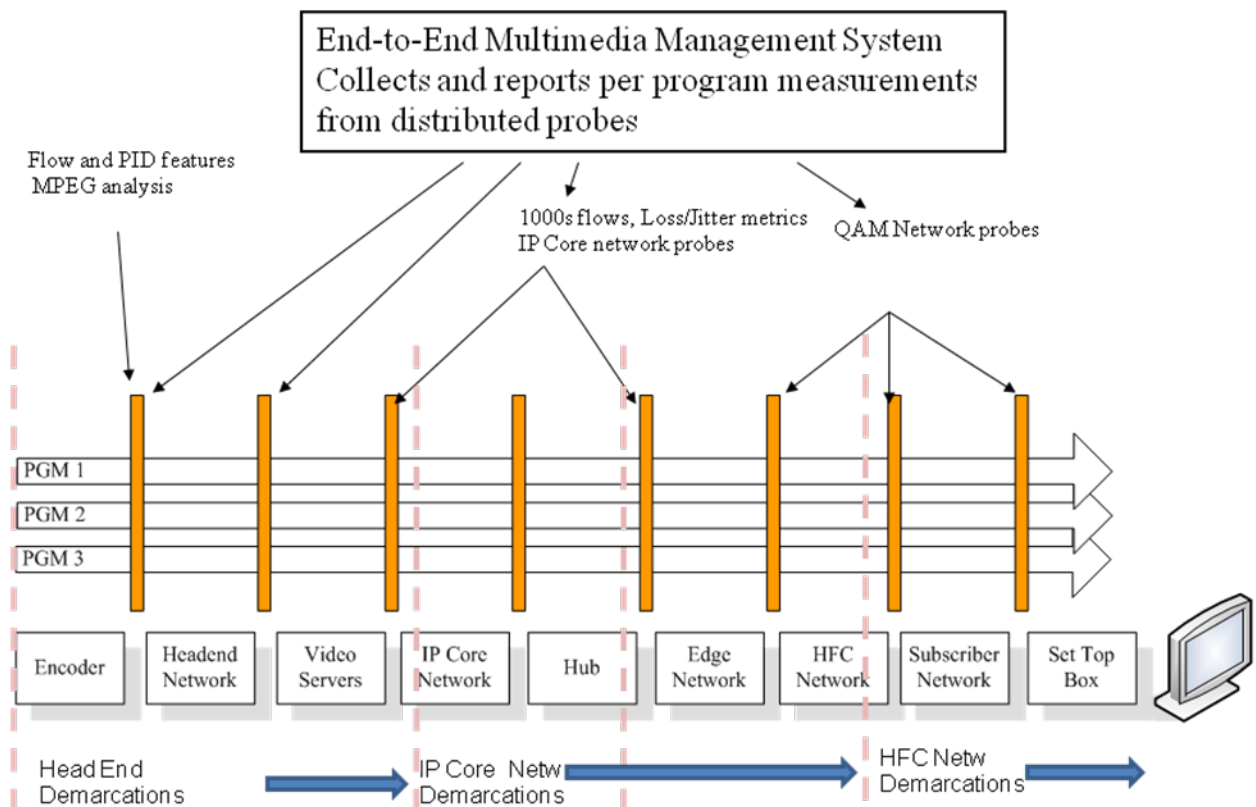


Figure 2: Distributed Simultaneous Program Monitoring

RECOMMENDATION-3. *To provide a cost effective solution for Multimedia Management and monitoring it is recommended that the particular set of parameters that might have been affected since the previous upstream monitoring location be measured and correlated. Supplementary metrics may also be necessary to gain sufficient information about an issue for precise fault location and repair.*

That is, if there are two measurement locations deployed, say at the input to a layer 2/ switch/router and at the output of a switch/router, the stream parameters of interest to measure are packet loss and jitter; namely, the stream parameters that can be affected by the device(s) between the measurement points. It would be redundant and unnecessary to measure the SCTE 142 Transport Stream Verification parameters since the payload is not modified by the switch/router. Likewise, if, for example, the two measurement points are widely separated across the distribution network at, say, the MPEG Encoder in the Head End and the QAM Modulator at a Hub Site, and devices such as multiplexers, rate shapers, DPI devices, etc. that do modify the Transport Stream are intervening, then all protocol encapsulation layers including SCTE 142 and IP metrics should be monitored