ATIS-0800008

QoS METRICS FOR LINEAR BROADCAST IPTV

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ATIS-0800008, *QoS Metrics for Linear Broadcast IPTV*

Is an ATIS standard developed by the **Quality of Service Metrics (QoSM)** Task Force of the **ATIS IPTV Interoperability Forum (IIF).**

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CONTRIBUTORS

Al Morton, AT&T
Robert Streijl, AT&T
David Hands, British Telecom
Simon Jones, British Telecom
John Williams, JDSU
Richard Brand, Nortel
Saurabh Srivastava, Nortel
Richard Brand, Nortel
Alan Clark, Telchemy
Paul McMenamin, Telchemy
Ken Kerpez, Telcordia Technologies
Kenneth Toney, Tektronix
Reza Shafiee, Verizon

ATIS Standard on

QoS Metrics for Linear Broadcast IPTV

1 INTRODUCTION

1.1 Overview/Background

This document defines an Alliance for Telecommunications Industry Solutions (ATIS) IPTV Interoperability Forum (IIF) consensus view of Quality of Service (QoS) metrics for Linear/Broadcast Internet Protocol TV (IPTV) service. Metrics, definitions, measurement points, and applicable measurements are identified. This is considered a living document as it is expected that additional metrics (and associated elements) will be defined as the industry and standards mature.

1.2 Goal

The goal of this document is to define a base set of QoS metrics for Linear/Broadcast IPTV service as defined per ATIS-0800002 [1] as completely as possible. ATIS IIF recognizes that as the IPTV architecture is currently a work in progress, not all QoS metrics applicable for the Linear/Broadcast IPTV service can be envisioned at this time. Additional QoS metrics will be added at a later time as more functional components of the architecture are defined – e.g., IP multicast specific, Digital Rights Management (DRM), metadata, service layer – as applicable.

1.3 Purpose

The purpose of this document is to provide the industry with an initial set of well defined QoS metrics that are deployable and immediately useful.

1.4 Scope and Assumptions

The following characteristics identify the scope of this document:

- It includes QoS metrics that are intended to support the Linear/Broadcast IPTV service defined in ATIS-0800002 [1], and not any other ATIS IIF defined IPTV services. However, it is recognized that many QoS metrics may also be applicable for other ATIS IIF defined IPTV services, such as Video On Demand (VOD), where many similarities exist.
- The QoS metrics apply to applicable measurement points, along an end-to-end path from the Video Head End (VHE) Egress to the IPTV Terminal Function (ITF) – AKA, Set Top Box (STB). Although not all information may be accessible (for example, due to encryption), the best possible view is provided where applicable and accepted by ATIS IIF.
- Many performance objectives will be architecture-dependent and therefore defining values/objectives for these QoS metrics may not be useful. There is a class or classes of QoS metrics that are independent of network architectures (i.e., service) and it may be appropriate to define values/objectives for these metrics. However, this is subject for further study and out of scope for this document.

- The current focus does not include an exhaustive analysis of associated service flows (e.g., DRM control/signaling) and considers this generally for further study, exceptions permitting – e.g., channel change by means of Internet Group Management Protocol (IGMP) joins and leaves.
- At this moment, the consumer domain is considered mainly from a fixed wireline home environment perspective and no specific consideration is given to Wireless Local Area Network (WLAN) and mobile environments. Analysis of such environments and the impact of the currently selected set of QoS metrics are for further study.
- At this time, ATIS IIF only considers video, audio, and the synchronization between audio and video in scope. Synchronization of subtitles with the Audio-Visual (AV) stream, closed captioning, emergency alerts, and other data/information types related to audio/video are for further study.
- At this time, ATIS IIF considers availability, usability and correctness of the Interactive Program Guide (IPG) out of scope and concentrates only on the responsiveness. Note that this document does not include Linear/Broadcast IPTV with trick modes.
- Measurement methodologies are for further study.

ATIS IIF recognizes that the IPTV VHE and Video Hub and Serving Offices (VHO, VSO) may require specific QoS metrics that could be different than the currently defined set of metric definitions. At this time, ATIS IIF recommends use of ETSI TR 101.290 [8] Motion Pictures Expert Group (MPEG) metrics and will consider the study of QoS metrics for this environment for further study.

It is assumed that the ITF at startup, before it reaches the service availability mode, will be involved in a variety of setup/control communications with any IPTV oriented network/service attachment functions in the Service Provider (SP)/Network Provider (NP) networks. At this time, ATIS IIF did not analyze the traffic in the control plane associated with this action to form any opinion on the need for QoS metrics, and considers this to be for further study.

ATIS IIF does not assume that only Real Time Protocol (RTP) is used, and allows MPEG Transport Stream (TS) directly over User Datagram Protocol (UDP) configurations. It is understood that when RTP is not used, this complicates accurate calculation of several metrics including dropped packets. Additional information/alternatives to calculate such metrics without RTP is for further study. In general, Transmission Quality metrics refer to IP packets.

2 LINEAR/BROADCAST IPTV

2.1 Service Description

ATIS-0800002 [1] describes Linear/Broadcast IPTV as corresponding to the classic form of television offered by cable, terrestrial broadcasters, and direct broadcast satellite providers. Satellite is shown only as an example. Logical domains have been introduced as follows: *Content Provider*, *Service Provider*, *Network Provider*, and *Consumer*. Based on these domains, the following depicts the Linear/Broadcast IPTV service.

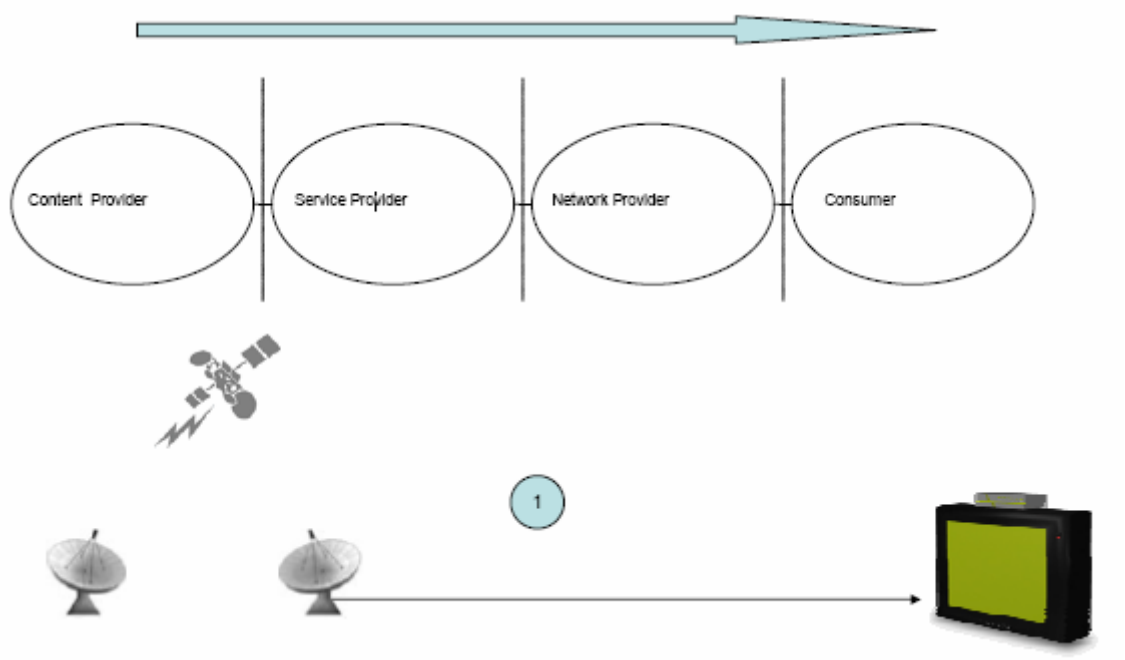

Figure 1: Linear/Broadcast TV (ATIS-0800002 [1]: Figure 6)

The Linear/ Broadcast IPTV service provides an essentially continuous stream flowing from the content provider to the ITF (i.e., STB) (Figure 1 shows an example ITF in the form of a STB on top of a TV). The SP may replicate the stream to multiple NPs using an Internet Protocol (IP) Multicast structure, and the NPs may replicate the stream for multiple consumer (e.g., home) networks. The SP may provide additional processing of the video stream (e.g., insertion of local content channels, advertising, etc). The service provider may receive content via satellite or other means. Content is acquired from some source such as a satellite downlink or land line feed and converted in a continuous stream of packets (see Flow 1 in Figure 1) for distribution and ultimate display on the TV screen.

Note that this service (and document) does not include Linear/Broadcast IPTV with trick modes.

2.2 Different Business Models

The Linear/Broadcast IPTV service may be offered in various ways, where one provider could fulfill multiple roles. Measurements may be restricted by domain. A domain may choose to share a subset (e.g., in aggregated form) of the amount of information resulting from the measurements. Hence, the business model may impact how and what can be measured. These business models should be taken into account when measurements of metrics are recommended.

The first example business model is where there are only distinct roles. Each provider implements one role.

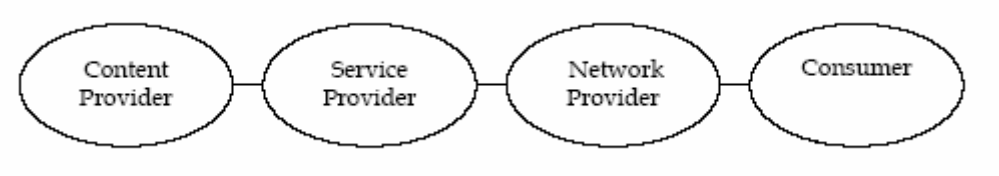

Figure 2: Four Distinct Logical Domains (ATIS-0800002 [1]: Figure 2)

The second example business model includes a provider that fulfills the service provider, network provider, and content provider roles as follows:

Figure 3: One Provider Implementing Multiple Providing Roles

In general, the relationship between the domains is one-to-many (e.g., multiple content providers provide service to a service provider). Within a domain it may be one-to-one or one-to-many.

2.3 Linear/Broadcast IPTV Measurement Points

Figure 4 indicates reference measurement points that will be referenced in 4.5, as part of the metric definitions.

This figure is based upon ATIS-0800004 [2] Figure 10. Three new measurement points, D^1, γ (gamma) and δ (delta) were added.

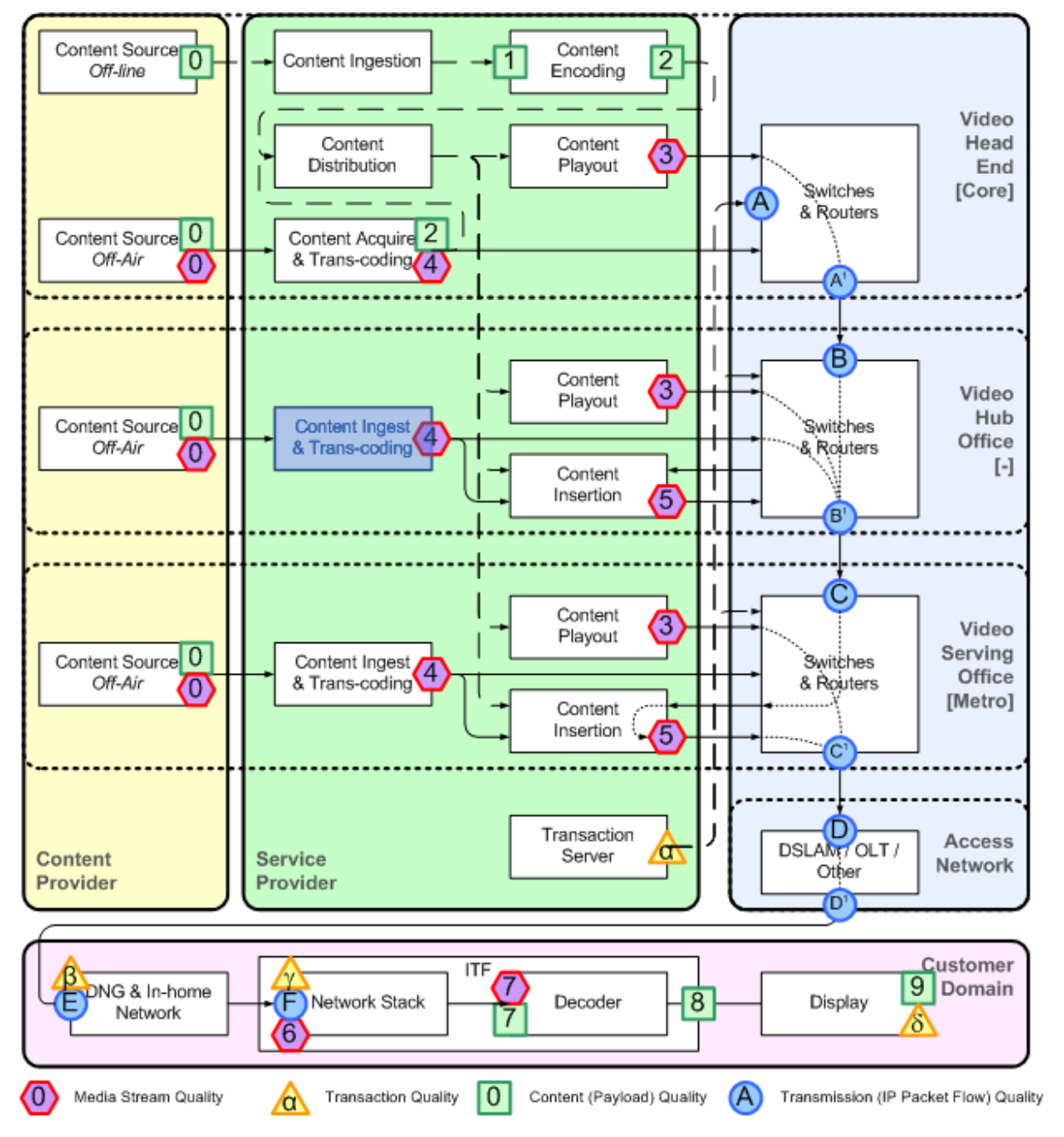

Figure 4: Linear/Broadcast IPTV Service's Architecture Model (ATIS-0800004 [2]: Figure 10)

3 USE CASES AND SERVICE REQUIREMENTS

As identified in ATIS-0800004 [2], use cases are used here in the analysis of QoS metrics for Linear/Broadcast IPTV to help define the scope of the service definition. From a service perspective, the following user-initiated actions can be observed in the Linear/Broadcast IPTV service:

1. A consumer turns on the STB.
2. A consumer uses the Interactive Program Guide (IPG) and selects an IPTV stream/channel.
3. A consumer watches an IPTV stream/channel.

4. A consumer chooses a different channel (channel change).
5. A consumer turns off the STB or switches to Video On Demand (VOD).

NOTE 1: Turning on/off the STB, and not the TV, is considered the more interesting scenario. At this time and in this document, the STB is considered to implement the ITF function.

NOTE 2: With respect to [2], use case scenarios 2 and 3 were combined into new use case 2.

This section includes service requirements, where applicable and considered in scope for this document, for the network operator (that has end-to-end control) or set of operators who need to track the performance of a stream/channel.

The following sections introduce example categories of QoS metrics for each use case. While many organizations of metrics are possible, at this time this topic is for further study. One example is to organize the metrics by speed, accuracy, and dependability requirements per ITU-T recommendation I.350 [5].

The actual QoS metrics proposed in this document in clause 4 are organized by their associated quality layers (transmission, media quality, transaction, and content).

3.1 A consumer turns on the STB

Turning on the STB includes the process of a user clicking an 'on'-type button. The time it takes for the STB to start up and be ready for service consumption is of interest to the consumer. The data traffic is all in the control plane. Example types of metrics include the boot time needed for the ITF Operating System (OS) to be ready, and the time it takes before the service application is functionally ready to receive consumer inputs.

3.2 A consumer uses the IPG and selects an IPTV program/channel

The user will use the IPG, also called EPG (Electronic Program Guide) to select services (e.g., channels) available to them. It is common that the user utilizes a remote control device to control the navigation through the EPG. The availability, usability, correctness, and responsiveness are some examples of the QoS metrics or criteria associated with the IPG.

At this time, ATIS IIF considers availability, usability, and correctness out of scope and concentrates on the responsiveness of the IPG. Services to support tracking of the Quality of Experience (QoE) for selecting a channel throughout the network is needed to determine problems with the creation or routing of a channel to an ITF. IGMP Join and Leave latency are considered important metrics as they bear on the time to show the new channel if the system must wait for the old channel to stop before the new channel will be transmitted. Also, channel changing may be blocked due to DRM and thus a DRM Metric will be tracked in the ITF to identify loss of service due to this reason.

3.3 A consumer watches an IPTV program/channel

This scenario can be characterized by the viewing/hearing experience of the service consumer. Many aspects of the service including problems in the video content quality, video transport, and IP transport layer performance can impact video. Example impairments of the video signal include blocking, blurring, edge distortion, etc. These impairments may be the result of various elements in the service delivery architecture. One example is the creation of a video stream to include advertisements (there

are several possible insertion points in the architecture). Also, the audio quality and the synchronization with the video signal are of importance. The data traffic is all in the data plane and is, in general, uni-directional (includes only receipt of signal).

At this time, ATIS IIF only considers video, audio, and the synchronization between audio and video in scope. Synchronization of subtitles with the AV stream, closed captioning, emergency alerts, and other data/information types related to audio/video are for further study.

Analysis of a specific Linear/Broadcast IPTV flow considers the following performance related concerns of particular interest:

- Time needed in the ITF by the application to process incoming packets and deliver the content to the MPEG decoder engine. This may also include conditional access / decryption processing.
- The ITF jitter buffer reaches the maximum level of its ability to smooth jitter set point prior to the forwarding of the video signal to the decoder function.

These metrics and other related ITF client processing delay metrics are for further study.

Several different types of IP and MPEG-TS errors can introduce video impairments. Analysis of methodologies to specifically identify the type and source of the error will be needed to effectively find a remedy for service degradation/blocking for channels currently being watched. Example categories of metrics include:

- IETF (IPPM WG) [11-20] and ITU-T [6, 7] metrics such as jitter, loss (delay beyond a threshold), gaps, bursts.
- IGMP leave latency (if old channel runs concurrent with new channel).
- DRM that may block content delivery.
- Retransmissions.
- ETSI TR 101 290 [8] measurement guidelines for DVB systems that include MPEG2-TS Metrics.

3.4 A consumer chooses a different channel (channel change)

The service consumer changes from one channel to another, but stays within the Linear/Broadcast IPTV service (as opposed to switching to another ATIS IIF IPTV service defined in ATIS-0800002 [1]). It is expected there may be some small performance differences depending on the IPTV service that is being selected, but this is for further study.

Linear/broadcast IPTV is generally supported using multicast transport techniques. The time to receive the new channel may be influenced by the location of the TV channel in the network, for instance at the DSLAM or further up in the network provider architecture (which involves one or more IGMP proxies). An example traffic flow and relevant types of information follows:

- Time between the user action and the transmission of the multicast messages (i.e., leave/join) to the network.
- Time taken for all network elements to process the multicast requests and the new multicast stream arrive at the ITF (i.e., ITF join latency and ITF leave latency).
- Time needed in the ITF by the application to process incoming packets and deliver the content to the MPEG decoder engine.
- The ITF jitter buffer reaches the maximum level of its ability to smooth jitter prior to the forwarding of the video signal to the decoder function.
- Time required in the ITF for the MPEG decoding process.

As indicated above, these metrics and other related ITF client processing delay metrics are for further study.

Network-oriented QoS metrics related to the switching between channels are considered in scope in this document. Examples of metrics will include channel change time/delay, IGMP Join, and IGMP Leave for watching network resources.

3.5 A consumer turns off the STB or switches to VOD

Turning off the STB includes the process of a user clicking an 'off'-type button. The user should not have to have any performance concerns in this scenario. Therefore, this scenario is mentioned for completeness only. The data traffic is all in the control plane.

As indicated before, it is expected there may be some small performance differences depending on the IPTV service that is being switched to, but this is for further study. No metrics are identified at this time.

4 LINEAR/BROADCAST IPTV METRICS AND MEASUREMENTS

This section defines metrics that satisfy the need for measurement of an end-to-end system based on the use cases from clause 3. This document includes a set of metrics, classified as *Recommended IPTV Metrics* and *Primary Metrics*, assumed to be universal and useful in all IPTV deployments across different networks. This is considered a living document as it is expected that additional metrics (and associated elements) will be defined as the industry and standards mature.

4.1 Defining Ancillary Information

The tables in this document give the definition of individual metrics. These metrics may sometimes be reported with differing durations, measurement periods, and accuracies; and they may be reported as individual values or aggregated statistics to varying reporting intervals. To provide flexibility without ambiguity, metrics are allowed to be reported as suits the purpose of the Operations Support System/Business Support System (OSS/BSS) operator, but are then fully defined when combined with ancillary information described here. This is colloquially called "header" information since it may appear only once in the header of a file containing many instances of metric values. This data may also reside in a configuration item.

The following applies to all metrics; however, any definitions specifically written in the tables take precedence over the general defining ancillary information described here. Default values may be accepted as being defining ancillary information when unambiguous.

Metrics are fully specified when accompanied by the following defining ancillary information:

- The name of the metric which this header refers to.
- Duration of each measurement:
  - Units of the duration (i.e., seconds, count).
- Is the metric a single measurement or a statistic.
- If the metric is a statistic, then:
  - What type of statistic (maximum, minimum, average, etc.).
  - Total number of measurements comprising the statistic.

Metrics should be specified with the following defining ancillary information:

- Accuracy.
- Limits (i.e., loss of more than x number of packets is indistinguishable due to sequence number size).
- Start time (Year-Month-Day Hour:Minute:Second).

4.2 Definition of Metric Behavior

- Counters stop incrementing at their maximum value – i.e., a 16 bit counter with a value of 65535 would not be further incremented until it has been reset to zero.
- Proportions are expressed as a binary fraction with the largest expressible proportion being 0xFFFF. For example, 0 would be expressed as 0x0000 and 1 as 0xFFFF.
- The type is the format for machine level communications and can be used to calculate a presentation value which is human-readable.
- Time periods are bounded by the largest expressible value, for example a 16 bit millisecond counter with a value of 65535 would represent a value of "65.535 seconds or greater."
- Alternate implementations that yield the same values as the implementation in this table are acceptable.
- Time intervals used for calculating proportions are in seconds. Jitter and delay are reported in milliseconds.
- Calculations that would divide by zero result in an output equal to zero.
- All metrics refer to a single IPTV stream.
- Mean Opinion Score (MOS) values are expressed as (a binary fraction) multiplied by 4 plus 1, with the largest expressible proportion being 0xFFFF. For example, 1 would be expressed as 0x0000 and 5 as 0xFFFF. Values can be decimal between 1 and 5, with 5 excellent and 1 bad.

4.3 Definition of Metric Accuracy

- Proportions and counters may suffer from minor inaccuracies or differences due to the definition of measurement interval/time and due to the potentially high variable rate of packets within an IPTV system. In measurements that rely on the 4 bit MPEG Transport continuity count, it should be noted that this can only be used to detect relatively short sequences of lost packets.
- Time delays should be measured with an accuracy of better than +/- 5 milliseconds. However, in some measurement points this may not be possible.
- Jitter levels should be measured with an accuracy of better than +/- 2 milliseconds. However, in some measurement points this may not be possible.
- ATIS IIF does not assume that only RTP is used and allows MPEG TS directly over UDP configurations. It is understood that when RTP is not used, this complicates accurate calculation of several metrics including dropped packets. Additional information/alternatives to calculate such metrics without RTP is for further study. In general, Transmission Quality metrics refer to IP packets.

4.4 Primary Metrics

The 4.5 Recommended IPTV metrics (see 4.5) are based on a set of 4.4 Primary Metrics. Table 1 describes these *Primary Metrics* and defines the basic building blocks for Table 2 (if applicable). These metrics represents basic metrics that could be measured in an end-to-end system. The definitions of the recommended metrics in Table 2 may include a set of *Primary Metrics* and propose one implementation of the metric.

Table 1: Primary Metrics

No.	Name	Definition	Type	Read (R)/ Write (W)	Comments
1	Total Packets Received	Total number of packets received in a measurement interval.	Counter	R	Packet type is identified in the header.
2	Total Packets Lost	Total number of packets lost or corrupted during a measurement interval.	Counter	R	Does not include discards.
3	Total Packets Discarded	Total number of packets discarded during a measurement interval.	Counter	R	Includes those lost due to late arrival or out of order arrival.
4	Total Bytes Received	Total number of bytes received in a measurement interval.	Counter	R	
5	Total Expected Bytes	Total number of bytes expected in a measurement interval.	Counter	R	
6	Total Expected Packets	Total number of packets expected in a measurement interval.	Counter	R	Packet type is identified in the header.
7	Out-of Order Packets	Number of packets out of order in a measurement interval.	Counter	R	See [20].
8	Gap Count	Number of gaps in a measurement interval. A gap is measured as an interval between two bursts.	Counter	R	See [19].
9	Gap Loss	Number of packets lost during a gap.	Counter	R	See [19].
10	Gap Length	Number of expected packets during gaps in a measurement interval.	Counter	R	See [19].
11	Burst Count	Number of bursts in a measurement interval. Burst is measured in a sliding window where more than one packet is lost.	Counter	R	See [19].
12	Burst Loss	Number of packets lost during bursts for a given measurement interval.	Counter	R	See [19].
13	Burst Length	Number of expected packets during a burst periods for a measurement interval.	Counter	R	See [19].
14	Burst Bytes Length	Number of expected bytes during a burst periods for a given measurement interval.	Counter	R	See [19].
15	Gmin Threshold	Minimum number of packets that must be received before and after a lost packet for the lost packet to be classified in a gap.	Counter	W	See [19].
16	MPEG2-TS PSI Error Threshold	Time when the PSI tables expected receive time is exceeded.	Time Measure milliseconds	W	Default value is 500 milliseconds and is used to increment a counter rather than an event as defined in [8].

No.	Name	Definition	Type	Read (R)/ Write (W)	Comments
17	MPEG2-TS Total Bytes per PID	Total number of bytes in an MPEG TS PID for a given measurement interval.	Counter	R	See [8].
18	MPEG2-TS Presentation Time Stamp (PTS) Error Threshold	Units of milliseconds when the interval between presentation time stamps expected receive time is exceeded.	Time Measure milliseconds	W	See [8].
19	Total Bytes per IPTV program/channel	Total number of bytes in an IPTV program/channel for a given measurement interval.	Counter	R	
20	Measurement Interval	Measurement window time period.	Time Measure Seconds	W	
21	Report Interval	Time to compile an array of QoS metrics to be reported.	Time Measure Seconds	W	
22	Sampling Interval	Interval of time at the end of which value of a variable is calculated.	Time Measure Seconds	W	
23	Loss Period Threshold	Threshold for minimum consecutive lost packet(s).	Counter	W	See [15].
24	Loss Distance Threshold	Maximum consecutive packets received between two "Loss Periods."	Counter	W	See [15].

4.5 Recommended IPTV metrics

This section contains ATIS IIF recommended Metrics for IPTV Broadcast service. These metrics are all read-only. They are organized by the quality layers defined in ATIS-0800004 [2]: Transmission Quality, Media Stream Quality, Content Quality, and Transaction Quality.

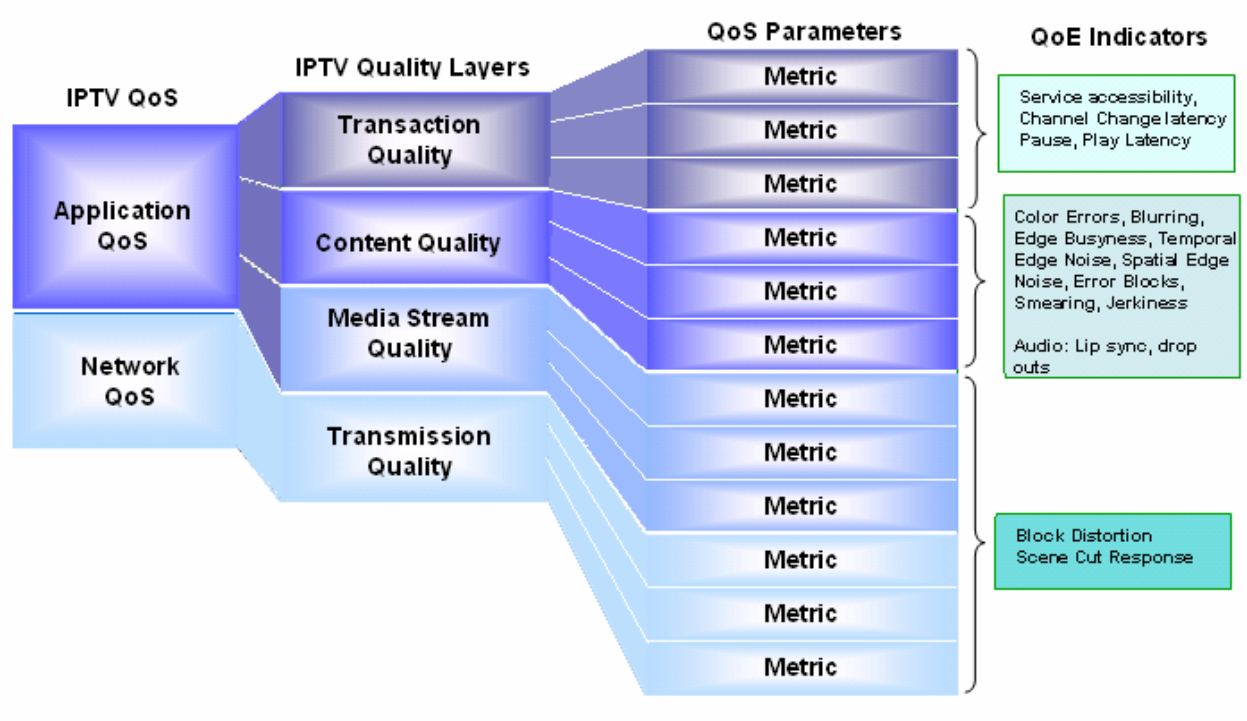

Figure 5: Classifying Quality Layers, QoS Parameters, and QoE Indicators (ATIS-080004 [2]: Figure 7)

This organization of the quality layers can be helpful in viewing the instrumentation methodology to be employed in a given network and at particular measurement points. Clause 2.5 of ATIS-0800004 [2] provides additional detail related to the above model and is included herein by reference. It should also be noted that the "Measurement Points" column defines the transmission layer points according to the overall quality model. As one reviews the table from top to bottom, metrics at the higher layers are defined. However, for simplicity, the same transmission points are indicated to denote physical place or point in the network. This is not to mean that the layer specific measurement point names are removed or are of no value.

Table 2: Recommended IPTV Metrics

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
Transmission Quality						
1	RTP Packet Loss Rate before Error Correction (EC)	Proportion of RTP packets lost in the network or discarded by Layer 1 or 2, expressed as a binary fraction of the Total Packets Lost divided by Total Packets Expected for a given Measurement Interval. See [22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of a consumer watching an IPTV program/channel without EC. Types of EC include Forward Error Correction (FEC) and Automatic Repeat reQuest (ARQ). Indicator of network errors
2	RTP Packet Loss Rate after EC	Packet loss rate after correction by FEC or retransmission expressed as a binary fraction of the Total Packets Lost divided by Total Packets Expected for a given Measurement Interval. See [22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of a consumer watching an IPTV program/channel and if EC needs to be adjusted to up the QoE. Applicable only if forward error correction or retransmissions or both are used. Measures the effectiveness of FEC/ ARQ mechanisms.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
3	RTP Packet Discard Rate	Proportion of RTP packets discarded due to late arrival expressed as a binary fraction of the Total Packets Discarded divided by the Total Packets Expected for a given Measurement Interval. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Indicates proportion of packets that are unusable either due to late arrival or arrival out of sequence (for decoders that cannot re-sequence packets). The definition of late arrival is system specific and will depend on playout buffer configuration. Identifies error events other than packet loss that would affect QoE.
4	Out of Order Packet Rate	Proportion of (IP or RTP) packets arriving out of order, expressed as a binary fraction of the Total Packets Out of Order divided by the Total Packets Expected for a given Measurement Interval. See [20].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Indicates proportion of packets that arrive out of order. Indicates network condition and some video decoders discard out of order packets.
5	RTP Burst Loss Rate before EC	Proportion of packets lost within (sparse) burst expressed as a binary fraction represented by the Burst Loss divided by Burst Counter. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Loss distribution before error correction. Indicates how severe transient loss conditions were. Useful for configuration of FEC and retransmission.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
6	RTP Burst Length before EC	Length of (sparse) burst periods (see Table 1 Burst Length). See [19, 22].	Counter	Unsigned 32 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Loss distribution before EC. Indicates how severe transient loss conditions were. Useful for configuration of FEC and retransmission.
7	RTP Gap Loss Rate before EC	Proportion of packets lost within gap periods represented by the Gap Loss divided by Total Packets Expected in the gap period. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Loss distribution before error correction. Indicates loss conditions during good quality periods.
8	Mean RTP Gap Length before EC	The mean length of gaps between bursts (see Table 1 Gap Length) in a Measurement Interval. See [19, 22]	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Loss distribution before error correction. Indicates loss conditions during good quality periods.
9	RTP Burst Loss Rate after EC	Proportion of packets lost within (sparse) burst periods represented by the Burst Loss divided by Burst Length. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Combined loss and discard distribution after error correction. Indicates the severity of transient problems affecting video quality.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
10	Mean RTP Burst Length after EC	Mean length of (sparse) burst periods (see Table 1 Burst Length). See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Indicates the severity of transient problems affecting video quality.
11	RTP Gap Loss Rate after EC	Proportion of packets lost within gap periods represented by the Gap Loss divided by Total Packets Expected in the gap period. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Combined loss and discard distribution after error correction. Indicates minor problems during good periods.
12	Mean RTP Gap Length After EC	The mean length of gaps between bursts (see Table 1 Gap Length) in a Measurement Interval. See [19, 22].	Proportion	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Combined loss and discard distribution after error correction. Indicates minor problems during good periods.
13	Smoothing Jitter	Delay variation due to deliberate smoothing of the (IP or RTP) packet flow in a sampling interval. In [22], it is referred to as peak smoothing Packet to Packet Delay Variation (PDV).	Time	Unsigned 32 bit milliseconds	At transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Transport jitter. Measured mostly in the Constant Bit Rate (CBR) environment. At the IP layer, if RTP is not available then Program Clock Rate (PCR) may be used. Indicates the scale of delay variations at the endpoint that are not due to network congestion.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
14	Peak Packet to Packet Delay Variation (PPDV)	IP or RTP Packet to Packet Delay Variation in a sampling interval.	Time	Unsigned 32 bit milliseconds	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. Indicates the scale of delay variations at the endpoint that are due to network congestion. Indicates instantaneous network jitter. See [18].
15	RTP Loss Period Count	The count of the number of times the loss period exceeded the Loss Period Threshold as defined in Table 1. See [15].	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This affects the ability to watch a channel. Indicates the frequency of very severe loss conditions where the video screen will go blank. Useful for setting EC parameters.
16	RTP Loss Distance Count	The count of times the number of received RTP packets between excess loss events is less than the excess Loss Distance Threshold as defined in Table 1. See [15].	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This affects the ability to watch a channel. Indicates the frequency of conditions where the video will flicker due loss of screen from excess loss and then receiving enough packets to recover the screen. Useful for setting EC parameters.
17	RTP Minimum Loss Distance	Minimum number of RTP packets between excess loss events. See [15].	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric is used for the watching of a program. It will report the minimum time between holes and can be used to determine if the ITF was able to recover and display the channel to the consumer. Useful for setting EC parameters.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
18	RTP Maximum Loss Period	Maximum number of RTP packets in an excess loss event (max hole size). See [15].	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric is used for the watching of a program. It will report the maximum time a screen will freeze or go blank. Useful for setting EC parameters.
19	Packet Retransmissions	Number of retransmitted RTP/UDP packets in a Measurement Interval.	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will help viewing reliability where retransmissions indicate a lost packet(s). Indicates error conditions and bandwidth usage.
Media Stream Quality						
20	MPEG2-TS Sync Loss Count	Count of loss of synchronization events at MPEG transport layer. See [8].	Counter	Unsigned 32 bit long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program.
21	MPEG2-TS Sync Byte Error Count	Count of Invalid MPEG transport sync byte indications. See [8].	Counter	Unsigned 32 bit long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. This affects the watching ability by the viewer.
22	MPEG2-TS Continuity Count Error Count	Count of incorrect packet order, duplicate packet or lost packet events at MPEG transport layer on a per PID basis See [8].	Counter	Unsigned 32 bit long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. This affects both the channel changing and watching ability of the viewer.
23	MPEG2-TS PID Error Count	Count of PID error occurrences defined as: PID does not occur for user specified time period. See [8].	Counter	Unsigned 32 bit long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric affects the ability of the consumer watching the IPTV Channel/Program. This affects both the channel changing and watching ability of the viewer.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
24	MPEG2-TS Program Specific Information (PSI) error Count	Sum of PAT_error, PAT_error2, PMT_error, and PMT_error2 as defined in [8] for each occurring event in a Sampling Interval that exceeds the MPEG2-TS PSI Error Threshold (see Table 1).	Counter	Unsigned 32 bit long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This affects both the channel changing and watching ability of the viewer. Indicates if MPEG stream association table elements are missing or errored. Reports an error if any of several conditions is in error.
Content Quality						
25	MOS-V	Video MOS, score that estimates the user-perceived picture quality. Ranges from 5 (Excellent) to 1 (Bad).[1] See [22].	MOS (number from 1 to 5)	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric is provided for the viewing (without sound) of a program. It is used to provide a scoring that can be used in other network types. Depends on source quality, image resolution, encoding, codecs, transmission, and error concealment.
26	MOS-A	Audio MOS, a 1-5 score that estimates the user-perceived audio quality Ranges from 5 (Excellent) to 1 (Bad). (See same footnote as MOS-V). See [22] .	MOS (number from 1 to 5)	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric is provided for the listening of a program. It is used to provide a scoring that can be used in other network types. Depends on source quality, audio quality, encoding, codecs, transmission, and error concealment.

[1] Algorithms used to estimate this metric are for further study by ATIS IIF.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
27	MOS-AV	Audio-Video MOS – a 1-5 score that estimates combined picture & audio quality and synchronization. Ranges from 5 (Excellent) to 1 (Bad). (See same footnote as MOS-V). See [22].	MOS (number from 1 to 5)	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric is provided for the watching of a program. It is used to provide a scoring that can be used in other network types. Depends on source quality, image resolution, audio quality, AV synchronization (i.e., lip synch), encoding, codecs, transmission, and error concealment.
28	MPEG2-TS Per PID bandwidth	Bandwidth per PID, excluding IP overhead = (Total Bytes per PID)*8/ (Sampling Interval).	Bit rate	Unsigned 32 bit long Bits per second (bps)	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will report bitrate of all PIDs to help identify congestion and packet loss related to an MPEG Elementary Stream (ES). Indicates error conditions and bandwidth usage.
29	Program/ channel Bandwidth	Total bandwidth of IPTV program/channel, including RTP, UDP and IP overhead. Excludes FEC in separate streams and retransmissions = (Total Bytes per program/channel)*8/ (Sampling Interval).	Bit rate	Unsigned 32 bit long Bits per second (bps)	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will ensure channel watching is available and that program channel does not cause congestion and packet loss. Useful for capacity allocation.
30	MPEG2-TS PCR Jitter	PCR jitter level. See [8].	Time	Unsigned 32 bit milliseconds	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will identify moments when channel selection and watching will not be possible due to misalignment of the PCR clock due to PCR jitter. MPEG system metric, but timing resolution is different. Millisecond resolution recommended.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
31	MPEG2-TS PCR Failures Count	Addition of PCR Error, PCR Repetition Error, and PCR Discontinuity Indicator Error counts in a Sampling Interval.	Counter	Unsigned 32 bit, long	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will identify moments when channel selection and watching will not be possible due to lack of PCR timing information to keep the PCR clock in alignment. Overall indication of PCR error types. See [8]
32	ITF buffer overruns	Total number of times the receive jitter buffer has overrun for this program/channel.	Counter	Unsigned 16 bit integer	Transmission measurement point F	This metric will report when the consumer screen will flicker or freeze. Buffer overflow in [21].
33	ITF buffer underruns	Total number of times the receive jitter buffer has underrun for this program/channel.	Counter	Unsigned 16 bit integer	Transmission measurement point F	This metric will report when the consumer screen will flicker or freeze. Buffer exhaust in [21].
34	AV Synch	The difference in playout time between audio and video streams. See [3].	Time	Unsigned 16 bit, milliseconds	Transmission measurement point F	The metric identifies when the watching of a channel is impaired by misaligned video and audio presentation. Also referred to as "Lip Synch." May be difficult to calculate, estimated value acceptable.
35	MPEG2-TS Proportion of I frames or slices impaired	The number of impaired I frames or slices divided by the total number of I frames or slices received.	Proportion	Unsigned 16 bit integer	Content quality measurement point 7	Other measurement points are possible in support of diagnostics.
36	MPEG2-TS Proportion of P and B frames or slices impaired	The number of impaired P and B frames or slices divided by the total number of P and B frames or slices received.	Proportion	Unsigned 16 bit integer	Content quality measurement point 7	Other measurement points are possible in support of diagnostics.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
37	MPEG2-TS Packet loss rate within I frames	The number of lost and discarded packets divided by the total number of packets expected within I frames.	Proportion	Unsigned 16 bit integer	Content quality measurement point 7	Other measurement points are possible in support of diagnostics.
38	MPEG2-TS Packet loss rate within P and B frames	The number of lost and discarded packets divided by the total number of packets expected within P and B frames.	Proportion	Unsigned 16 bit integer	Content quality measurement point 7	Other measurement points are possible in support of diagnostics.
Transaction Quality						
39	IGMP Join Latency	Elapsed time from IGMP join message transmission to receipt of first video packet of target media stream.	Time	Unsigned 16 bit, milliseconds	Transmission measurement points: D, D[1], E, F.	This affects the user experience at times that the user chooses and changes to another channel. Other measurement points are possible in support of diagnostics.
40	IGMP Leave Latency	Elapsed time from IGMP leave message transmission to receipt of last video packet of target media stream.	Time	Unsigned 16 bit, milliseconds	Transmission measurement points: D, D[1], E, F.	This affects the user experience at times that the user chooses and changes to another channel. Other measurement points are possible in support of diagnostics.
41	Channel Change Delay	Elapsed time from the time an ITF requests a different channel to the time video is fully rendered on the display screen.	Time	Unsigned 16 bit, milliseconds	Transmission measurement point: F	This affects the user experience at times the user chooses and changes to another channel. Other measurement points are possible in support of diagnostics.

No.	Name	Definition	Units	Type	Measurement Points	Comments (incl. justification/usefulness of the metric)
42	DRM Error	Number of distinct service-affecting failure events of the DRM system.	Counter	Unsigned 16 bit, integer	Transmission measurement point: F	The metric will help with channel changing and watching of a program that is stopped because of the DRM system. Counts discrete failure events of the DRM system, creates visibility of DRM faults that are likely to affect service.
43	MPEG2-TS Service Impairments Error	Service_Impairments_Error See [8], clause 5.5.3.	Counter	Unsigned 16 bit integer	All transmission MPs: A, A[1], B, B[1], C, C[1], D, D[1], E, F	This metric will identify moments when channel selection and watching may be impaired. Number of occurrences when MPEG service is available but impaired.
44	IPG Transaction Delay	The elapsed time from when the IPG client in the ITF requests IPG (service) data from the transaction server to the time it is received.	Time	Unsigned 16 bit, milliseconds	Transaction points Alpha and Beta	Affects the speed at which program guide screens are updated, if the ITF is not able to cache the information.
45	ITF OS Boot Time	The elapsed time from when the ITF power is turned on until the operating system is ready.	Time	Unsigned 32 bit, milliseconds	Transmission measurement point: F	Threshold values may be appropriate for these metrics.
46	ITF Service Boot Time	The elapsed time from when the OS is functional until the service application screen is viewed and the ITF is online and ready for subscriber input with service availability.	Time	Unsigned 32 bit, milliseconds	Transmission measurement point: F	ITF initialization involves a series of authorization, discovery, and other transactions, this metric helps identify problems in this chain. Threshold values may be appropriate for these metrics.

5 TERMINOLOGY

5.1 Glossary

5.1.1 Measurement Instrumentation: Measurement instrumentation refers to the ability of a device to support appropriate measurements. This device or equipment may be a dedicated measurement system or a device or equipment that is involved in the end-to-end IPTV service delivery, such as an ITF.

5.1.2 Quality of Experience (QoE): Describes the user's experience. QoE can be broadly grouped: i.e., picture QoE, transaction QoE, audio QoE, and multimedia QoE. QoE may be calculated or estimated numerically using sets of QoE indicators and/or QoS metrics.

5.1.3 Quality of Experience (QoE) Indicators: Individual performance indicators that can be experienced by a user. Include video indicators such as picture error blocks, transaction indicators such as channel change delay, audio indicators, and multimedia indicators.

5.1.4 Quality of Service (QoS) Metrics: Measures of technical performance. Includes network QoS metrics such as packet loss and application QoS metrics such as VoD server errors.

5.1.5 Use Case: A use case is an external view of a system that represents an action or sequence of actions the user might perform in order to complete a task.

5.2 Acronyms

ARQ	Automatic Repeat reQuest
ATIS	Alliance for Telecommunications Industry Solutions
AV	Audio Visual
BSS	Business Support System
CBR	Constant Bit Rate
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DVB	Digital Video Broadcasting (project)
EC	Error Correction (FEC or retransmission)
EPG	Electronic Program Guide
ES	Elementary Stream (MPEG)
ETSI	European Telecommunications Standards Institute
FEC	Forward Error Correction
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IIF	IPTV Interoperability Forum
IP	Internet Protocol
IPG	Interactive Program Guide
IPPM-WG	IETF – IP Performance Metrics – Working Group
IPTV	Internet Protocol TeleVision
ITF	IPTV Terminal Function
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
MOS	Mean Opinion Score

MP	Measurement Point
MPEG	Motion Picture Experts Group
NP	Network Provider
OS	Operating System
OSS	Operations Support System
PAT	Program Association Table
PCR	Program Clock Rate (MPEG TS)
PDV	Packet to Packet Delay Variation
PID	Program Identifier (MPEG TS)
PMT	Program Mapping Table
PPDV	Peak Packet to Packet Delay Variation
PSI	Program Specific Information (MPEG TS)
PTS	Presentation Time Stamp (MPEG TS)
QoE	Quality of Experience
QoS	Quality of Service
QoSM	Quality of Service Metrics
RFC	Request For Comments (IETF documents)
RTP	Real-Time Protocol
SP	Service Provider
STB	Set Top Box
TS	Transport Stream
UDP	User Datagram Protocol
VHE	Video Head End
VHO	Video Hub Office
VOD	Video On Demand
VSO	Video Serving Office
WLAN	Wireless Local Area Network

6 REFERENCES

6.1 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

6.1.1 ATIS[2]

[1] ATIS-0800002, *IPTV Architecture Requirements*, ATIS IIF, May 16, 2006.

[2] ATIS-0800004, *A Framework for QoS Metrics and Measurements supporting IPTV Services*, ATIS IIF, October, 2006.

[2] These documents are available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < https://www.atis.org/docstore/default.aspx >

6.1.2 ITU[3]

[3] ITU-R BT1359-1, *Relative timing of sound and vision for broadcasting*, November 1998.

[4] ITU-T G.1020 *SERIES G: Transmission systems and media, digital systems and networks: Performance parameter definitions for the quality of speech and other voice band applications utilizing IP networks.*

[5] ITU-T Recommendation I.350, *SERIES I: Integrated Services Digital Network: General aspects of quality of service and network performance in digital networks, including ISDNs,* March 1993.

[6] ITU-T Recommendation Y.1540, *SERIES Y: Global information infrastructure and Internet protocol aspects: Internet protocol data communication service, IP packet transfer and availability performance parameters*, December 2002.

[7] ITU-T Recommendation Y.1541, *SERIES Y: Global information infrastructure and Internet protocol aspects: Internet protocol data communication service, Network performance objectives for IP-based services*, February 2006.

6.1.3 ETSI[4]

[8] ETSI TR 101 290 v1.2.1, "*Digital Video Broadcast (DVB); Measurement Guidelines for DVB Systems.*"

6.1.4 DSL Forum[5]

[9] DSL Forum TR-98, *DSLHome™ Gateway Device Version 1.1 Data Model for TR-069*, September 2005.

[10] DSL Forum TR-126, *Triple-Play Services Quality of Experience (QoE) Requirements,* December 2006.

6.1.5 IETF[6]

[11] RFC 2330, *Framework for IP Performance Metrics*, May 1998.

[12] RFC 2679 *A One-way Delay Metric for IPPM*, September 1999.

[13] RFC 2678, *IPPM Metrics for Measuring Connectivity*, September 1999.

[14] RFC 2680, *A One-way Packet Loss Metric for IPPM*, September 1999.

[15] RFC 3357, *One-way Loss Pattern Sample Metrics*, August 2002.

[16] RFC 3393, *IP Packet Delay Variation Metric for IP Performance Metrics (IPPM)*, November 2002.

[17] RFC 3432, *Network Performance Measurements with Periodic Streams*, November 2002.

[18] RFC 3550, RTP*: A Transport Protocol for Real-Time Applications*, July 2003.

[19] RFC 3611, RTP *Control Protocol Extended Reports (RTCP XR)*, November 2003.

[20] RFC 4737, *Packet Reordering Metrics*, November 2006.

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[3] These documents are available from the International Telecommunications Union. < http://www.itu.int/ITU-T/ >

[4] This document is available from the European Telecommunications Standards Institute (ETSI).
< http://www.etsi.org/getastandard/home.htm >

[5] These documents are available from the DSL Forum. < http://www.dslforum.org/techwork/treports.shtml >

[6] These documents are available from the Internet Engineering Task Force (IETF). < http://www.ietf.org >

6.2 Informative Reference

The following drafts contain provisions that, through reference in this text, constitute provisions of this report. At the time of publication, the editions are indicated as working text. All drafts are subject to revision, and parties to agreements based on this draft are encouraged to investigate the possibility of applying the most recent editions of the draft or, if standardized, moving it to the normative reference section.

6.2.1 DSL Forum[7]

[21] DSL Forum WT-135, *Data Model for a TR-069 Enabled STB*.

6.2.2 IETF[8]

[22] IETF Draft *RTCP XR - IP Video Metrics Report Blocks*,
< http://tools.ietf.org/id/draft-clark-avt-rtcpxr-video-02.txt >.

[7] This document is available from the DSL Forum. < http://www.dslforum.org/techwork/tworkinprogress.shtml >

[8] This document is available from the Internet Engineering Task Force (IETF). < http://www.ietf.org >