TECHNICAL REPORT

TR-160
IPTV Performance Monitoring

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Issue History

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Executive Summary

TR-160 addresses IPTV Performance Monitoring from the Broadband Network Gateway to the Set Top Box assuming a BroadbandSuite™ 3.0 Network Architecture. It describes a comprehensive set of performance indicators and how these can be derived from measurements in the network elements. An overview of the management infrastructure required to provide performance monitoring for end-to-end Quality of Service and demarcation is given and the use of resource performance data discussed.

1 Purpose and Scope

1.1 Purpose

It is apparent from Broadband Forum Technical Report TR-126 that IPTV services carried over the broadband access network require a particular level of Quality of Service (QoS) to support adequate Quality of Experience (QoE). Emerging networks have the capability to deliver a specified QoS but in some circumstances QoS may deteriorate such that, although the IPTV service continues to work, there would be an unacceptable QoE. In more severe cases, network issues lead to a complete disruption of service. TR-160 discusses performance monitoring for networks supporting IPTV in a BroadbandSuite 3.0 architecture. It provides a comprehensive set of service performance indicators and indicates how these may be obtained from accessing performance and other parameters from network elements by a management infrastructure. This data can be use to provide an indication of end-to-end performance and for demarcation.

1.2 Scope

TR-160 focuses on IPTV delivered across a BroadbandSuite 3.0 capable network architecture (see Figure 1). The Broadband Forum's BroadbandSuite 3.0 Release provides an end-to-end architecture for IPTV delivered over VDSL2, ADSL2Plus and GPON. Included in this release is TR-101, defining an Ethernet centric architecture satisfying all requirements specified in TR-058 and adding the QoS and multicast capabilities necessary to support IPTV. The BroadbandSuite 3.0 Release aims to add GPON and VDSL2 as supported interfaces in the TR-101 architecture. TR-160 identifies mechanisms for monitoring QoE and demarcating performance issues from the Broadband Network Gateway to the Set Top Box to one of three network regions:

1. within the Access Network,
2. within the Regional Broadband Network or in the Application Service Provider domain,
3. at the Customer Premise.

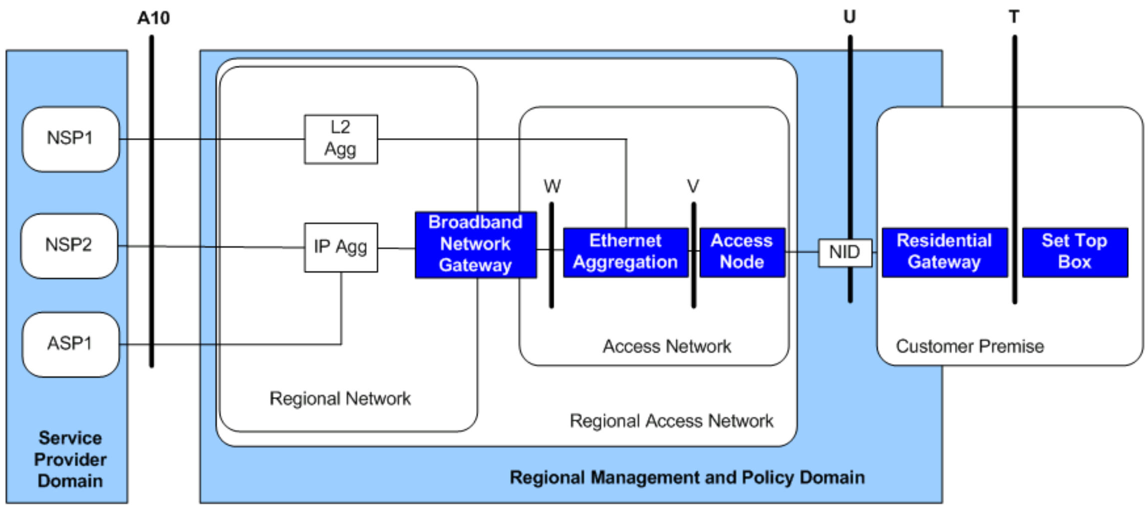


Figure 1 TR-160 Scope based on a TR-101 Reference Architecture

This Technical Report assumes an end-to-end network architecture designed to meet QoE requirements specified in TR-126. The Performance Monitoring described herein is intended to capture and isolate scenarios in which network quality degrades. Details of network configuration in support of TR-126 QoE targets are beyond the scope of TR-160.

2 References and Terminology

2.1 Conventions

In this Technical Report, several words are used to signify the requirements of the specification. These words are always capitalized. More information can be found be in RFC 2119.

SHALL This word, or the term "REQUIRED", means that the definition is an absolute requirement of the specification.

SHALL NOT This phrase means that the definition is an absolute prohibition of the specification.

SHOULD This word, or the adjective "RECOMMENDED", means that there could exist valid reasons in particular circumstances to ignore this item, but the full implications need to be understood and carefully weighed before choosing a different course.

SHOULD NOT This phrase, or the phrase "NOT RECOMMENDED" means that there could exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications need to 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 one of an allowed set of alternatives. An implementation that does not include this option SHALL be prepared to inter-operate with another implementation that does include the option.

2.2 References

The following references are of relevance to this Technical Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Technical Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

[1]	TR-126	*IPTV Quality of Experience*	Broadband Forum	2006
[2]	TAM GB929 2.0	*TM Forum Applications Framework*	TMF	2008
[3]	ITU-T H.222.0; ISO/IEC 13818-1	*Information technology -- Generic coding of moving pictures and associated audio information: Systems*	ITU; ISO/IEC	05/2006; 2007
[4]	RFC 5101	*Specification of the IP Flow*	IETF	2008

		Information Export (IPFIX) Protocol for the Exchange of IP Traffic Flow Information		
[5]	TR-135	*Data Model for a TR-069 Enabled STB*	Broadband Forum	2010
[6]	GB938 0.8	*Application Note to SLA Management Handbook*	TMF	2008

2.3 Abbreviations

This Technical Report uses the following abbreviations:

ASP	Application Service Provider
CBR	Constant Bit Rate
DVB	Digital Video Broadcasting
GOP	Group of Pictures
HD	High Definition (TV)
IPTV	Internet Protocol Television
KPI	Key Performance Indicator
KQI	Key Quality Indicator
LP	Loop Provider
MOS	Mean Opinion Score
NAP	Network Access Provider
NID	Network Interface Device
NSP	Network Service Provider
NPVR	Network Personal Video Recorder
PVR	Personal Video Recorder
RCA	Root cause Analysis
RG	Residential Gateway
RNP	Regional Network Provider
QoE	Quality of Experience
QoS	Quality of Service
SD	Standard Definition (TV)
STB	Set-Top Box
VBR	Variable Bit Rate
VSP	Video Service Provider

3 Technical Report Impact

3.1 Energy Efficiency

TR-160 is not intended to have a direct impact on Energy Efficiency but it is recognised that improved diagnostics may reduce energy usage by, for example, reducing unnecessary truck rolls.

3.2 IPv6

TR-160 has no impact on IPv6.

3.3 Security

Performance monitoring raises the security issue of performance management interfaces, typical of any telecommunication management system, being secured against abuse using appropriate security practices.

4 IPTV Application Overview

TR-126 [1] describes IPTV and corresponding QoE requirements in detail including the following illustration of an end-to-end IPTV system (see Figure 2).

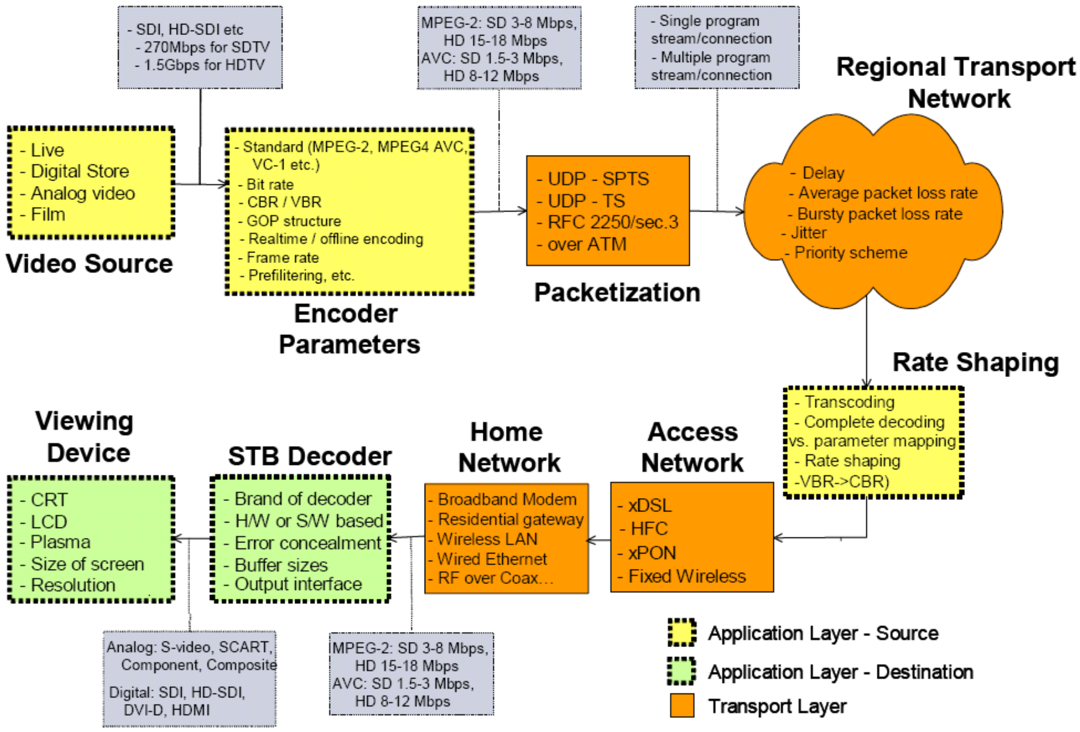


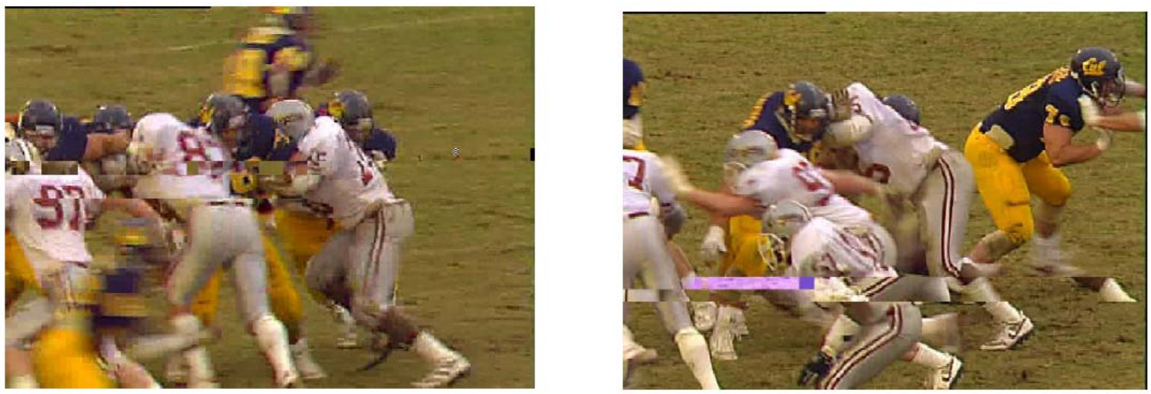
Figure 2 End-to-End Video Services Delivery (taken from Figure 5/TR-126)

What follows is a brief synopsis of IPTV characteristics to better support the rest of this document. The reader is encouraged to review TR-126 for an in-depth understanding.

IPTV emulates Broadcast television with IP Multicast distribution of content, only delivering a given channel to those users who have requested it and obtaining the benefits of Multicast in that multiple users can utilise a single source stream. IPTV utilises IGMP signalling from the Set Top Box to the Access Node to communicate channel changes. When connectivity issues exist (e.g. no picture on the screen), IGMP must be included in the troubleshooting process. IPTV also enables Video on Demand – whereby an IPTV stream is unicast to a single user. Thus, IPTV may be Multicast or Unicast and provisions must exist in support of monitoring and troubleshooting both service type.

There are three fundamental types of issues that can impact IPTV QoE:

1. Degraded service – often referred to as tiling or macro blocking, this occurs when some amount of the IPTV stream is unavailable to the Set Top Box at playout time. This is most commonly due to packet loss at some point in the network but could be due to everything from content encoding issues to delay-variations (jitter) when packets arrive too late at the STB. An illustration of degraded service from TR-126 is shown in Figure 3.



Single B-frame IP packet loss

Single I-frame IP packet loss

Figure 3 – IPTV Packet Loss (taken from Figure 11/TR-126)

2. Unavailable service – this may be caused by any number of things but the symptom is always the same, no TV picture on the screen.
3. Insufficiently responsive service – this could be long channel change times or delay in responsiveness of "trick play" features when using Video on Demand (pause, fast-forward, rewind, etc).

These fundamental service impairment types provide an application layer anchor to discuss performance requirements, diagnostics and corresponding best practices for proactive QoE management and optimal responsiveness to QoE issues.

5 End-to-End Service Delivery Model

Figure 4 shows the component parts of an end-to-end network delivering IPTV. An IPTV *video service flow*[1] passes through a series of routers in the regional network and switches in the aggregation network and over the transmission systems that interconnect them. At each router or switch there are queues which can introduce variable delay and, if the queue buffers become too full, packet loss. All transmission systems can experience transmission errors that may result in packet loss. In practice the transmission systems between routers and switches in the regional and aggregation networks are optical systems that have an extremely low error rate and so are not likely to be significant contributors to performance degradation. DSL Access Media and home networking technology are more likely to experience transmission errors arising from electromagnetic interference.

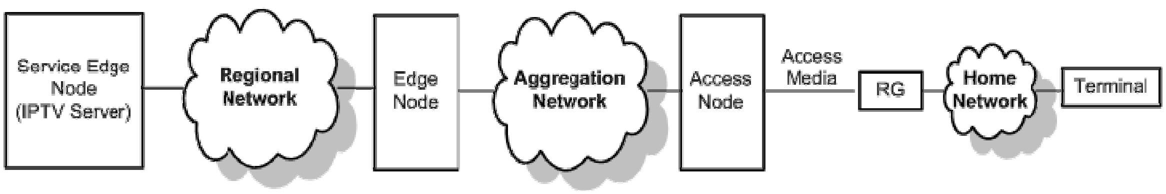


Figure 4 – IPTV End-to-End Network Components

Whatever the means used to try to deliver video packets with an acceptable QoS the statistical nature of packet transmission and the interference in transmission systems means that at times the QoS may deteriorate. Traffic peaks, faults or configuration errors and noise could all result in unacceptable throughput, packet loss, delay or jitter.

When QoS does deteriorate the user may experience degraded QoE which, if serious, may then result in a customer complaint. When this happens it is vital that tools are available for the rapid demarcation and diagnosis of the problem so that remedial action can be taken by the appropriate business entity.

[1] The word flow is much used and poorly defined leading to confusion. In TR-160 the term video service flow has been adopted and is defined as the sequence of packets that deliver a video picture.

6 Business Model

There are several different business models for the delivery of IPTV. The business model impacts performance monitoring in two ways. The first is that demarcation is required between the domains of the providers in the supply chain. The second is that some capabilities for performance monitoring may be restricted to one of the domains and not available to other providers. Figure 5 shows a generic delivery network and the business entities that operate the different parts of the end-to-end network. The Video Service Provider (VSP) delivers IPTV service via a Service Edge Node to the regional network (owned by the Regional Network Provider (RNP)). To get to a specific user the service goes to an access Edge Node that provides connectivity over an aggregation network to an Access Node (all owned by the Network Access Provider (NAP)). The Access Node provides connectivity over Access Media which may be owned by a Loop Provider (LP)) to a RG (owned by the end user or a Network Service Provider (NSP) and managed by the NSP). There may be other Service Providers (not shown in the figure) providing analogue voice over the local loop and Internet Access over the broadband access network from other service nodes on the regional network.

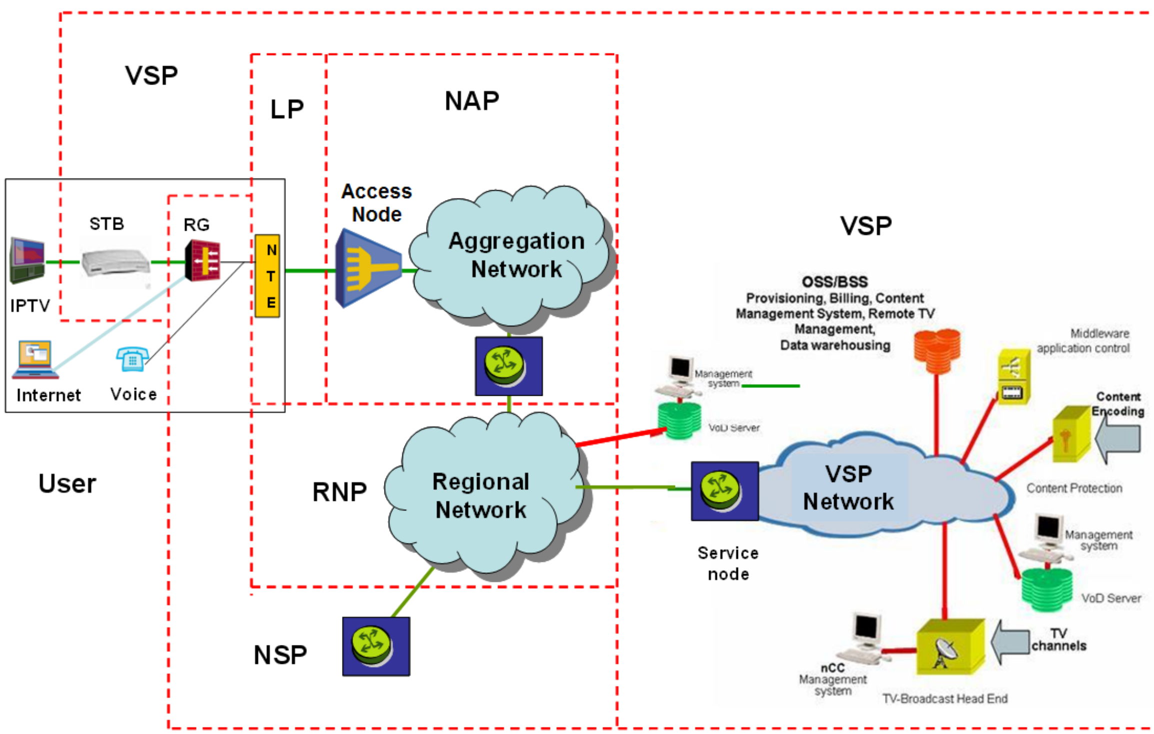


Figure 5 – Business Entities and Architecture

This business model is the most general. In many situations and countries where regulation may not force multiple business entities, some of these roles will coalesce into composite businesses. However, as the component parts of the network still exist it is probable that the operational entities will still exist within larger business entities and so it is useful to consider the most general model. The effect of combining business entities is that the access to performance monitoring tools in different domains is possible without defining business to business interfaces.

7 Performance Monitoring Overview

The various component parts of the end-to-end network are equipped with a variety of functions that can detect faults but in general there is little capability to establish that a particular video service flow is experiencing a deterioration of QoS. Ideally there needs to be a means at the boundary of each domain to measure the QoS parameters for a particular service flow. This is illustrated in Figure 6 where monitoring points are indicated at nodes at the domain boundaries.

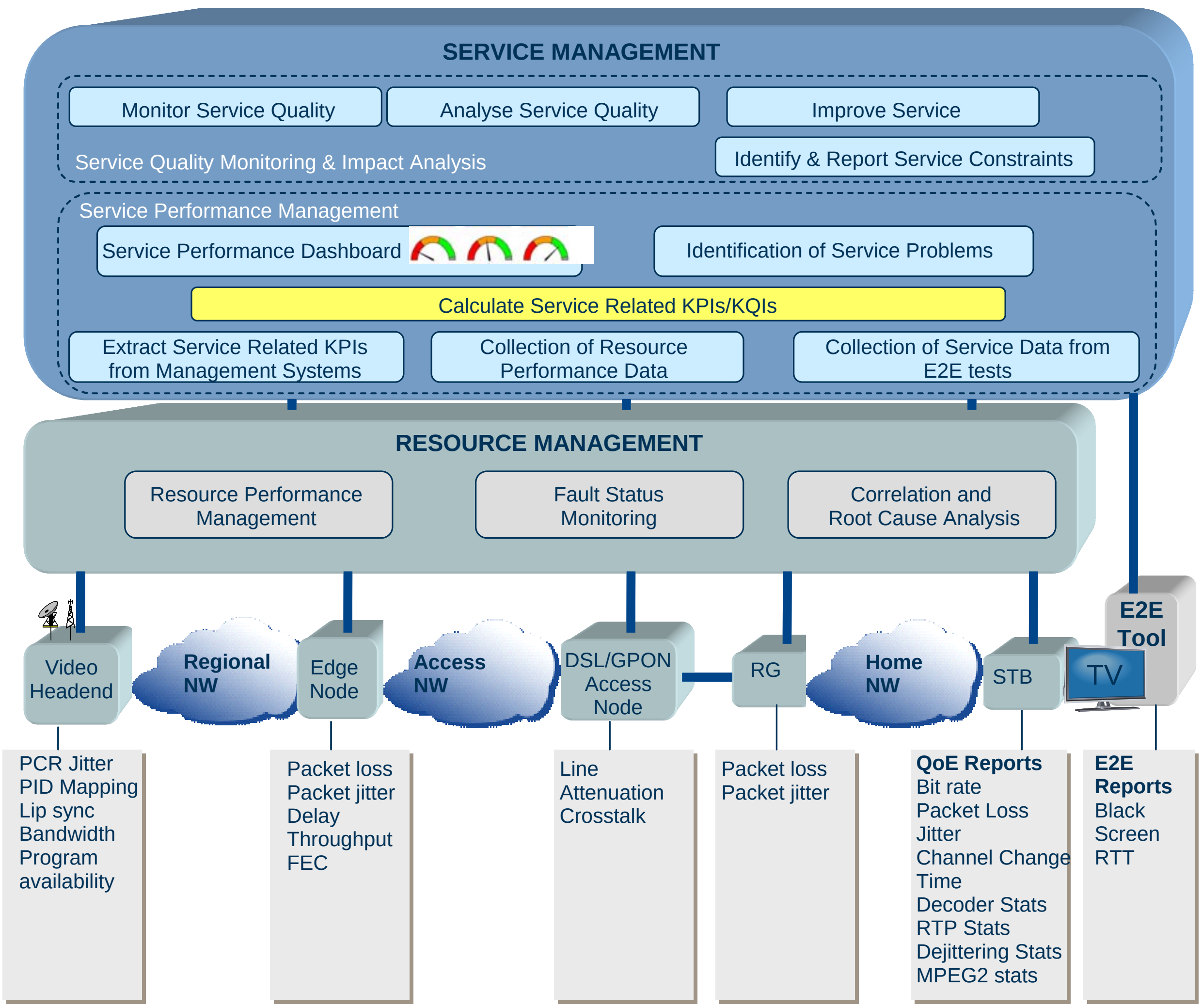


Figure 6 – Monitoring points

7.1 Service Management Assurance Architecture

The IPTV Performance Monitoring concept builds on the TAM 3.0 Service Management Assurance Architecture [2], and consists of Service Management and Resource Management functions.

7.1.1 Service Quality Monitoring & Impact Analysis

Service Quality Monitoring (SQM) and impact analysis applications are designed to allow operators to determine what levels of service they are delivering to their customers. Ideally these take a customer-centric view, i.e. the quality of service perceived by customers, but may measure additional service metrics to allow the operator to be aware of impending problems or degradations to service. Impact analysis applications extend this capability to predict the likely impact of service degradations or network problems on specific customers.

Key features are:

- Monitor Service Quality
  - Extracts service related key performance indicators (KPIs) from various management systems.
  - Receives alarm information.
  - Receives test information.
- Analyze Service Quality
  - Collates the KPIs and converts to Key Quality Indicators (KQIs) against which the service quality can be measured.
- Improve Service
  - Recommends improvements as a result of the Service Quality Analysis.
- Identify & Report Service Constraints
  - Identifies areas within the network where service deterioration is being caused by constraints such as demand surges.
  - Reports these to the resource layer.

7.1.2 Service Performance Management

Service Performance Management Applications help monitor the end-to-end services, including the customer's experience. This can include a real-time, end-to-end view to ensure that each service is functioning correctly and a historical view. These applications build on the Resource Performance data and active end-to-end service performance test data to provide a view of a service. These applications provide a key input to determine the Quality of Service.

Key features are:

- Collection of Resource Performance data
- Collection of Service Performance data through end-to-end tests
- Calculate Service related KPIs and KQIs
- Identification of Service related problems

7.1.3 Resource Correlation & Root Cause Analysis

Correlation is the ability to collect various events in the network and through a transformation process reduce the number of raw events to a manageable amount to enable a user to move into the area of Root Cause Analysis (RCA). RCA enables the network operator to quickly determine the root cause of a problem in the network. Correlation & Root Cause applications are often part of an overall resource problem management solution, but have a unique role in mediating network alarms with topology and configuration data.

7.1.4 Resource Performance Management

Applications in this area of the Applications Map can be sub-divided into:

- Resource Performance management

- Resource Data Mediation

Traditionally, the management of network resources has been geared to managing the technology that supports the network-monitoring events. With multi-service networks it will be managed according to the services being delivered across the network-monitored on service levels.

As the services and the network infrastructure that supports them become more complex, automation of the data analysis is required.

7.1.5 Fault Status Monitoring

These applications are responsible for monitoring the administration and operation status of the resource. These applications ensure that the operational personnel always have the correct and latest operational status of the resource.

These applications also ensure that any changes to the network topology (configuration) are reflected in the dependent systems – performance management, service management etc. Also changes in load on resources are reflected. This means that the setting of relevant thresholds and observing the passing of these is within the capabilities supported by such applications.

7.2 Service KPI Calculations

The System Service Assurance Manager will provide capability to calculate the KPIs according to pre-defined rules and formulas. The following main data sources can be found:

1. QoE reports from STBs
2. Performance information from the Resource Management domain
3. E2E Measurements from Intrusive/Non-Intrusive probes

QoE information needs to be collected as close as possible to the end user, preferably in the STB. Depending on the number of QoE reporting STBs, information from Resource Management and probes may also be needed.

If we want to measure media quality at the monitoring points, three methods may be distinguished:

- Full reference: a reference video is available in the network and correlations are made between the reference video and video received at the monitoring point,
- Reduced (or partial) reference: the correlation is carried out between the video received and spatiotemporal information extracted from the reference,
- No reference: there is no comparison with a reference; measures are executed on the video received.

The full reference method is good for tests in the laboratory or prior to in-service transmission because it can be awkward to place a reference video in an in-service network and to measure it. The no reference algorithms are probably more suited to use in a live network.

7.3 Resource Performance Data

The monitoring that is needed at each node is dependent on what QoS performance parameters need to be measured. In general there are four parameters of interest:

- Throughput
- Packet loss
- Jitter
- Delay

7.3.1 Throughput Measurement

To measure throughput requires that a counter accumulates the number of bytes in the relevant packets passing a point over a specified time interval. To be effective the monitoring must distinguish between relevant packets and those that belong to other services. The means to do this will depend on the architecture and protocols used to transport the video service. For example, if a single video stream is associated with an IP source address and is going to a specific destination address then counting all the bytes in packets with the specific source and destination addresses will be appropriate.

7.3.1.1 PID based Throughput Measurement

Video or audio packets in the MPEG2-TS need to have a unique PID. The PID value is provisioned during the MPEG multiplexing stage. The measurement of throughput requires that a counter accumulates the number of bytes associated with a specific PID that are passing a point over a specified time interval. Null packets (stuffing) used to create CBR (constant bit rate) stream have a fixed PID of 8191 specified by the MPEG standard. The ability to measure throughput based on PID's will allow isolating and troubleshooting problems affecting IPTV QoE. Video throughput, audio throughput and null packet throughput all need to be measured.

7.3.2 Packet Loss Measurement

Packet loss has a major impact on IPTV quality of experience (QoE) and can occur for many reasons including external events (for example, electrical impulse noise, lightning, noise interference on xDSL lines, system reconfiguration and/or traffic congestion).

IPTV packet loss leads to pixelization or blocking, freeze frame and/or set-top box lockup, and the degree of impact is dependent on the type of video frame that is affected. Through the IPTV video compression process, three types of frames are generated: I-frames, P-frames and B-frames (i.e., intra frames, predicted frames, and bipredictive frames).

The I-frames serve as the reference for all frames in a Group of Pictures (GOP). Therefore, loss of part or all of an I-frame propagates and can persist for the entire GOP. Similarly, P- and B-frames can be referenced by other frames and similar issues could be experienced but usually to a lesser extent and of shorter duration. The more flexible inter-picture prediction of H.264 can worsen this effect.

Packet loss can also create longer channel change times (zap time). During channel change, decoders wait for the next reference I-frame before presenting the image to the viewer; packet loss during this frame can cause the decoder to wait until the next good frame, thus significantly increasing channel-changing time.

Packet loss performance requirements are defined in terms of loss period and loss distance. The loss period measures the duration of an error event, while the loss distance measures the time between packet losses. Broadband Forum recommendation TR-126 defines desirable loss distance as: one error in one hour for standard-definition (SD) programming and one error in four hours for high-definition (HD) programming, at loss periods of 16 ms.

To detect the loss of a packet in an individual video service flow then the sequence numbers in either TCP or RTP need to be monitored. A break in the sequence indicates a lost packet. With TCP when there is retransmission of a lost packet the discontinuous sequence numbers arising from the retransmission have to be ignored.

Packet Loss measurement can be performed by monitoring RTP or MPEG2-TS protocol layers. In case of RTP based packet loss measurement it is common to monitor the Sequence Number field continuity over a period of time. When MPEG2-TS based packet loss measurement is utilized then Continuity Counter fields are monitored for continuity, although the Continuity Counter has too low a resolution to provide a reliable measure of the packet loss rate.

7.3.3 Jitter Measurement

7.3.3.1 Packet Inter-arrival Jitter

To measure the delay jitter on the video service flow requires that the service flow packets are identified and the time each packet arrives recorded. The jitter is calculated from the time difference between the arrival of adjacent packets.

Packet Inter-arrival Jitter is an estimate of the statistical variance of the RTP data packet inter-arrival time which is measured based on the RTP time stamp. The inter-arrival jitter is defined to be the mean deviation of the difference in packet spacing at the receiver compared to the sender for a pair of packets. The inter-arrival jitter should be calculated continuously as each data packet is received from the same source. The jitter calculation must allow profile-independent monitors to make valid interpretations of reports coming from different implementations.

7.3.3.2 PCR Jitter

Transport stream (TS) is a format specified in MPEG-2 Part 1 [3]. It combines audio, video and other data into packets of 188 bytes (184 bytes of payload and 4 bytes of packet header). When transmitted over IP these 188 byte packets are encapsulated into UDP datagrams which typically contains seven packets of 188 bytes each. Included in this Transport Stream are clock synchronizing parameters that are sent at regular time intervals. These clock synchronizing fields, called Program Clock Reference (PCR), are the instantaneous value or a sample of the 27 MHz System Time Clock (STC) located at the MPEG video encoder. The PCR in the Transport Stream permits the MPEG decoder to recreate the encoder's System Time Clock. This recreated clock guarantees that the decoded video output operates at the same rate as the video signal input to the MPEG encoder.

Reference [3] specifies a maximum interval of 100 ms between consecutive PCR values. The Digital Video Broadcasting (DVB) organization recommends that all DVB compliant systems will transmit the PCR values with a maximum interval of 40 ms. However, all receivers should work properly with intervals as long as 100 ms. The standards do not insist that the interval be constant.

At the receiver the regeneration of the 27 MHz system clock for the program under the decoding process is controlled by a signal that makes use of each of the PCR values corresponding to that program at the time of arrival to introduce corrections when needed. It is assumed that the stability of the clock regenerator is such that the phase does not unduly drift from one PCR value to the next over intervals as long as 100 ms. However, it is the responsibility of the TS to provide the values of PCR correctly with an error no greater than 500 ns from the instantaneous phase of the system clock. The limit of 500 ns may be exceeded as an accumulated error over many PCR values and it should be considered in terms of its drift contribution. This value however, specifically excludes the specific or impairments of the transport layer.

MPEG2-TS transmitted over any real network will be exposed to certain effects caused by the network components which are not ideally transparent. One of the predominant effects is the acquisition of jitter in relation to the PCR values and their position in the TS. If the PCR values do not arrive with sufficient regularity then this clock may jitter or drift. Recovery of the PCR allows the decoder (STB) to synchronize its clock to the same rate as the original encoder clock. High PCR jitter levels may cause the receiver/decoder to go out of lock, which will affect the video displayed on the TV. In addition if over time the STB acquires drift then typically the video and the voice may go out of sync affecting the QoE as well.

7.3.4 Delay Measurement

Delay measurements are by definition between two nodes in a network. Direct measurement of delay on the stream of packets of a single video flow requires the logging of the time each packet passes each node. The clocks at each node need to be locked to a master reference clock.

7.3.5 Resource Performance Data Sources

As indicated above the resource performance parameters are at the network layer level and thus do not address QoE measurements directly. Packet loss measurement could be more accurate if, for instance, the I-, B-, and P-frames of the video flow could be distinguished: loss of I-frames is more relevant than loss of B- or P-frames. However, such measurements would need more computational capabilities in the network. Moreover, it may be impossible to analyze encrypted or content protected video streams. Delay jitter measurement may be also inadequate in some cases: for instance, if video transport is VBR coded.

However these parameters provide a good starting point for measuring QoS of IPTV transmission. Extra metrics providing something closer to the user experience should complement network layer parameters: for instance some current work being conducted in the VQEG (Video Quality Expert Group) deals with an objective quality method, which may be computed in the network in the future (it consists of partial video signal analysis in order to simulate QoE seen by the client: frequency response, contrast sensitivity, etc.).

Unfortunately network elements do not universally provide performance data for individual service flows. The IETF has specified the IP Flow Information Exchange (IPFIX) [4] as a mechanism for supporting the measurement of the performance of individual flows and exporting the data to a data collection function, but this requires processing to be introduced at each node. The means of obtaining adequate per flow performance data from the key nodes of the network or how to process what aggregated data is available are subjects for further study.

8 Service Performance Indicators

Service Key Performance Indicators (KPIs) and Service Key Quality Indicators (KQI) are used to monitor the performance of the IPTV service with focus on QoE (see [2]).The KPIs reflect the end-user perception of the IPTV service performance and the trigger points for the measurements are therefore defined as close as possible to the end-user, typically in the STB. To account for cases where the actual end-user perception is not practically measurable in an automated manner, trigger points are also defined on signals that are directly measurable in the network, albeit giving only an approximation of the end-user experience.

For each KPI, there is a description on how the KPI can be calculated using the STB data model described in TR-135 [5]. For a general discussion of KPI calculations, see Section 7.2.

The KQI is another way of presenting a KPI which shows the percentage of session with degraded performance (see [6]).

The following key performance indicators are defined within this Technical Report:

1. IPTV Portal Information Retrieval Time
2. IPTV Service Access Time
3. IPTV Channel Switching Time
4. IPTV Video on Demand Access Time
5. IPTV Video on Demand Access Success Ratio
6. IPTV Video on Demand Completion Ratio
7. IPTV Video on Demand Control Response
8. IPTV Media Quality
9. IPTV IP Packet Loss
10. IPTV Channel Availability
11. IPTV Video without Disturbance

8.1 IPTV Portal Information Retrieval Time

8.1.1 KPI IPTV Portal Information Retrieval Time [s]

The parameter KPI IPTV Portal Information Retrieval Time describes the duration (in seconds) from requesting specific information from the portal until the reception and display of the last information packet at the client (STB).

8.1.1.1 Corresponding QoE Objective

TR-126 EPG Navigation Response (6.1.1, 6.2.1)

8.1.1.2 Abstract Equation

$$IPTV\ \ Portal\ \ Information\ \ Retrieval\ \ Time[s] = \\ t(information\ \ received) - t(information\, request\, sent\, by\, client)$$

8.1.1.3 Trigger Points

Event from abstract equation	Trigger points from user's point of view	Technical description / protocol view
Information request sent by client	Start: User pushes button on remote control that initiates the retrieval	The STB sends TCP SYN (the three way handshake) prior to first HTTP message
Information received	Stop: The requested information is displayed on the screen	The STB receives the last HTTP message carrying the information

8.1.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.GlobalOperation.Sample.
Parameter	PortalResponse

The PortalResponse parameter is a comma and colon-separated list, where a comma separates measurements made in different sample intervals and a colon separates individual measurements within a specific sample interval. The KPI is calculated directly from the PortalResponse parameter by converting the sample values from milliseconds to seconds.

8.1.2 KQI IPTV Portal Information Retrieval Performance [%]

The parameter KQI IPTV Portal Information Retrieval Performance describes the percentage of portal information retrievals where the portal information retrieval time is less than or equal to a predefined threshold time.

8.1.2.1 Abstract Equation

$$KQI\ IPTV\ Portal\ Information\ Retrieval\ Performance\,[\%] =$$

$$\frac{\sum (PIR\ where\ KPI\ IPTV\ Portal\ Information\ Retrieval\ Time\ \leq\ RT\ threshold)}{total\ number\ of\ PIR} \times 100,$$

where $PIR\ =\ portal\ information\ retrievals$

and $RT\ =\ retrieval\ time.$

8.1.3 Comments

In a thin client approach the portal information is cached in the client (STB), so the access to information is normally very fast. However, the KPI covers the case when access to non-cached information is requested and the client needs to interact with the IPTV middleware.

Example of portal information use cases: opening the ESG menu, browsing in the EPG, opening the VoD catalogue, browsing the VoD catalogue, etc.

8.2 IPTV Service Access Time

8.2.1 KPI IPTV Service Access Time [s]

The parameter KPI IPTV Service Access Time describes the duration (in seconds) from start of service (including STB) until the default channel is presented on the screen.

8.2.1.1 Corresponding QoE Objective

TR-126 System Start-up Time (6.1.1, 6.2.1)

8.2.1.2 Abstract Equation

$$IPTV\ Service\ Access\ Time[s] = t(1st\ media\ packet\ displayed) - t(TV\ application\ start)$$

8.2.1.3 Trigger Points for IPTV

Event from abstract equation	**Trigger points from user's point of view**	**Technical description / protocol view**
TV Application Start	Start: Pushing of button that starts the STB	First message (e.g; DHCP Discover) sent by STB during boot-up
Client displays 1st media packet for both audio and video	Stop: The default channel is displayed on the screen including both video and audio[2]	First multicast I-frame displayed by the STB

8.2.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.GlobalOperation.Total.
Parameter	ServiceAccessTime

The KPI is calculated directly from the ServiceAccessTime parameter by converting it from milliseconds to seconds.

8.2.2 KQI IPTV Service Access Performance [%]

The parameter KQI IPTV Service Access Performance describes the percentage of service access attempts where the service access time is less than or equal to a predefined threshold time.

[2] From an end-user perspective, the channel is considered displayed on the screen when the complete picture has been drawn on the screen, not when it begins to be drawn on the screen.

8.2.2.1 Abstract Equation

$$KQI\ IPTV\ Service\ Access\ Performance\ [\%] = \frac{\sum(service\ access\ attempts\ where\ KPI\ IPTV\ Service\ Access\ Time\ \leq\ SAT\ threshold)}{total\ number\ of\ service\ access\ attempts} \times 100,$$

where $SAT = service\ access\ time.$

8.2.3 Comments

The KPI covers the startup and boot of the STB until the default channel (assuming such exists) is displayed on the screen. The protocol view in the KPI is a less accurate estimate of the end-user experience because of the delay that can be expected from the boot of the STB until the first message (e.g; DHCP Discover request) is sent.

8.3 IPTV Channel Switching Time

8.3.1 KPI IPTV Channel Switching Time [s]

The parameter KPI IPTV Channel Switching Time describes the time taken to switch from one TV channel to another (aka channel zapping). The duration is measured from the request to change the channel until the channel switch request is completed.

8.3.1.1 Corresponding QoE Objective

TR-126 Channel Change Speed (6.1.1, 6.2.1, 6.3)

8.3.1.2 Abstract Equation

$$IPTV\ Channel\ Switching\ \ Time\,[s] = t(channel\ switch\ request\ completed) - t(channel\ switch\ request\ sent\ by\ client)$$

8.3.1.3 Trigger Points IPTV

Event from abstract equation	Trigger points from user's point of view	Technical description / protocol view
Channel switch request sent by client	Start: User request new channel by pushing button on the remote control	First IGMP message sent by the STB
Channel switch request completed	Stop: The new TV channel is displayed on the screen including both video and audio[3]	First multicast I-frame displayed by the STB

[3] From an end-user perspective, the channel is considered displayed on the screen when the complete picture has been drawn on the screen, not when it begins to be drawn on the screen.

8.3.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.VideoResponseStats.
Parameter	VideoSystemResponse

The VideoSystemResponse parameter is a comma and colon-separated list, where a comma separates measurements made in different sample intervals and a colon separates individual measurements within a specific sample interval. The KPI is calculated directly from the VideoSystemResponse parameter by converting the sample values from milliseconds to seconds.

The ServiceType of the MainStream instance must be equal to "IPTV".

8.3.2 KQI IPTV Channel Switching Performance [%]

The parameter KQI IPTV Channel Switching Performance describes the percentage of channel switches where the channel switching time is less than or equal to a predefined threshold time.

8.3.2.1 Abstract Equation

$$KQI\ IPTV\ Channel\ Switching\ Performance\ [\%] = \frac{\sum (CS\ where\ KPI\ IPTV\ Channel\ Switching\ Time\ \le\ ST\ threshold)}{total\ number\ of\ CS} \times 100,$$

where $CS\ =\ channel\ switches$

and $ST\ =\ switching\ time.$

8.3.3 Comments

The KPI covers channel switching regardless of source, i.e. it also covers the case when the end-user switches between channels delivered by different content providers.

8.4 IPTV Video on Demand Access Time

8.4.1 KPI IPTV Video on Demand Access Time [s]

The parameter KPI IPTV Video on Demand Access Time describes the duration (in seconds) from requesting specific content until the display of the first information packet on the screen.

8.4.1.1 Corresponding QoE Objective

None applicable.

8.4.1.2 Abstract Equation

$$IPTV\ Video\ On\ Demand\ Access\ Time\ [s] = t(content\ displayed) - t(request\ sent\ by\ client)$$

8.4.1.3 Trigger Points IPTV

Event from abstract equation	Trigger points from user's point of view	Technical description / protocol view
Request sent by client	Start: Pushing of button on remote control	Session setup request (RTSP Setup/SIP Invite) sent by the STB
Content displayed	Stop: Requested content is displayed on the screen[4]	First I-frame of unicast stream displayed by the STB

8.4.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample. VideoResponseStats.
Parameter	VideoSystemResponse

The VideoSystemResponse parameter is a comma and colon-separated list, where a comma separates measurements made in different sample intervals and a colon separates individual measurements within a specific sample interval. The KPI is calculated directly from the VideoSystemResponse by converting the sample values from milliseconds to seconds.

The ServiceType of the MainStream instance must be equal to "VoD".

8.4.2 KQI IPTV Video on Demand Access Performance [%]

The parameter KQI IPTV Video On Demand Access Performance describes the percentage of VoD access attempts where the VoD access time is less than or equal to a predefined threshold time.

8.4.2.1 Abstract Equation

$$KQI\ IPTV\ Video\ on\ Demand\ Access\ Performance\ [\%] =$$

$$\frac{\sum(VA\ where\ KPI\ IPTV\ Video\ on\ Demand\ Access\ Time\ \leq\ VAT\ threshold)}{total\ number\ of\ VA} \times 100,$$

$$\text{where}\ VA\ =\ VoD\ access\ attempts$$

$$\text{and}\ VAT\ =\ VoD\ access\ time.$$

8.4.3 Comments

The KPI covers all on demand content such as unicast streamed video, NPVR, etc. It covers the initial access of the content (the session setup). Any trick playing (pause, FF, REW, play after pause etc) is covered by the KPI Video on Demand Control Response Time.

[4] From an end-user perspective, the content is considered displayed on the screen when the complete picture has been drawn on the screen, not when it begins to be drawn on the screen.

8.5 IPTV Video on Demand Access Success Ratio

8.5.1 KPI IPTV Video on Demand Access Success Ratio [%]

The parameter KPI IPTV Video on Demand Access Success Ratio describes the probability (as a percentage) that a requested Video on Demand (VoD) session is accessed successfully. The Video on Demand Access Success Ratio is expressed as the ratio of successful access attempts and the total number of access attempts. The information is considered successfully accessed if the access of the content progresses far enough for it to be displayed on the screen. Otherwise the access attempt is considered failed.

8.5.1.1 Corresponding QoE Objective

None applicable.

8.5.1.2 Abstract Equation

$$IPTV\ Video\ on\ Demand\ Access\ Success\ Ratio\left[\%\right] = \frac{Number\ of\ successful\ VoD\ access\ attempts}{Total\ number\ of\ VoD\ access\ attempts} \times 100$$

8.5.1.3 Trigger Points

Event from abstract equation	Trigger points from user’s point of view	Technical description / protocol view
Number of successful VoD access attempts	An attempt is defined successful when the desired content is displayed on the screen.	The number of successful session setup requests (RTSP Setup/SIP Invite) sent by the STB. An attempt is defined successful when the first I-frame is displayed by the STB.
Total number of VoD access attempts	Includes all retrieval attempts, also those that didn't end in the display of the requested information.	The number of session setup requests (RTSP Setup/SIP Invite) sent by the STB. Includes also those attempts that didn't end in the receiving of the first I-frame.

8.5.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.VideoResponseStats.
Parameter	AccessSuccesses RequestedTransactions

The parameters are comma-separated lists, where each entry is the success and failure counts during a sample interval. For each sample interval, the KPI is calculated as

$$IPTV\ Video\ on\ Demand\ Access\ Success\ Ratio\left[\%\right] = \frac{AccessSucceses}{RequestedTransaction} \times 100$$

The ServiceType of the MainStream instance must be equal to “VoD”.

8.5.2 KQI IPTV Video on Demand Access Success Performance [%]

The parameter KQI IPTV Video on Demand Access Success Performance describes the percentage of KPI IPTV Video on Demand Access Success Ratio reports where the ratio is greater than or equal to a predefined threshold percentage.

8.5.2.1 Abstract Equation

$$KQI\ IPTV\ Video\ on\ Demand\ Access\ Success\ Performance\ [\%] = \frac{\sum(KPI\ IPTV\ Video\ on\ Demand\ Access\ Success\ Ratio\ \geq\ VASR\ threshold)}{total\ number\ of\ KPI\ IPTV\ Video\ on\ Demand\ Access\ Success\ Ratio\ reports} \times 100,$$

where $VASR\ =\ VoD\ access\ success\ ratio.$

8.5.3 Comments

The KPI covers all on demand content such as VoD pay-per-view, NPVR, etc.

An attempt is defined successful when the first content is displayed on the screen, i.e. when the first I-frame has been displayed by the STB, not when the complete content has been sent.

8.6 IPTV Video on Demand Completion Ratio

ID: IPTV_VoD_comp

8.6.1 KPI IPTV Video on Demand Completion Ratio [%]

The parameter KPI IPTV Video on Demand Completion Ratio describes the probability (as a percentage) that a VoD session is successfully completed once it has been successfully established. A session is completed successfully if it is successfully started and continues until it is intentionally terminated by the end-user. The Video on Demand Completion Ratio is expressed as the ratio of successfully completed VoD sessions and the total number of successful VoD access attempts.

8.6.1.1 Corresponding QoE Objective

None applicable.

8.6.1.2 Abstract Equation

$$IPTV\ Video\ on\ Demand\ Completion\ Ratio\ [\%] = \frac{Number\ of\ successfully\ completed\ Video\ on\ Demand\ sessions}{Total\ number\ of\ successful\ Video\ on\ Demand\ access\ attempts} \times 100$$

8.6.1.3 Trigger Points

Event from abstract equation	**Trigger points from user's point of view**	**Technical description / protocol view**
Number of successfully completed VoD sessions	A session is defined as successfully completed when the access attempt is successful and the content continues to be displayed on the screen until the end-user pushes a button to end the content	The number of successfully completed VoD sessions. A session is defined as successfully completed if it continues until a protocol request (RTSP/SIP) to end the session is sent by the STB.
Total number of successful VoD access attempts	Includes all successful VoD access attempts whether or not they are completed successfully	The number of successful session setup requests (RTSP Setup/SIP Invite) sent by the STB. Includes all successful access attempts, also those that end in another way than through a protocol request from the STB

8.6.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.VideoResponseStats.
Parameter	AccessSuccesses CompletionCount

The parameters are comma-separated lists, where each entry is the success and completion counts during a sample interval. For each sample interval, the KPI is calculated as

$$IPTV\ Video\ on\ Demand\ Completion\ Ratio\ [\%] = \frac{CompletionCount}{AccessSuccesses} \times 100$$

The ServiceType of the MainStream instance must be equal to "VoD".

8.6.2 KQI IPTV Video on Demand Completion Performance [%]

The parameter KQI IPTV Video on Demand Completion Performance describes the percentage of KQI IPTV Video on Demand Completion Ratio reports where the ratio is greater than or equal to a predefined threshold percentage.

8.6.2.1 Abstract Equation

$$KQI\ IPTV\ Video\ on\ Demand\ Completion\ Ratio\ Performance\ [\%] = \frac{\sum (KPI\ IPTV\ Video\ on\ Demand\ Completion\ Ratio\ \geq\ VCR\ threshold)}{total\ number\ of\ KPI\ IPTV\ Video\ on\ Demand\ Completion\ Ratio\ reports} \times 100,$$

where $VCR = VoD\ completion\ ratio.$

8.6.3 Comments

The KPI covers all on demand content such as VoD pay-per-view, NPVR, etc.

8.7 IPTV Video on Demand Control Response

8.7.1 KPI IPTV Video on Demand Control Response [s]

The parameter KPI IPTV Video on Demand Control Response describes the duration (in seconds) from requesting a change of playout speed for a VoD until the display of the first information packet by the client (STB). For technical and practical reasons, the only Video on Demand Control Response time that is possible to define and measure unambiguously is the “play delay”, i.e. the time period from when the “Play” button is pressed on the remote control to the time the content is displayed on the screen. The Video on Demand Control Response time is only measured when starting from a non-play state, i.e. either idle or paused.

8.7.1.1 Corresponding QoE Objective

TR-126 VoD Control Response (6.1.1, 6.2.1)

8.7.1.2 Abstract Equation

$$IPTV\ Video\ on\ Demand\ Control\ Response\ Time\ [s] = t(play\ out\ speed\ changed) - t(request\ sent\ by\ client)$$

8.7.1.3 Trigger Points

Event from abstract equation	Trigger points from user’s point of view	Technical description / protocol view
Request sent by client	Start: Pushing of button on remote control	Protocol request (RTSP/SIP) to start playing unicast stream is sent by the STB
Play out speed changed	Stop: Content is displayed on the screen with the requested	First I-frame of unicast stream displayed by the STB

	speed[5]	

8.7.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.VideoResponseStats.
Parameter	VoDControlResponse

The VoDControlResponse parameter is a comma and colon-separated list, where a comma separates measurements made in different sample intervals and a colon separates individual measurements within a specific sample interval. The KPI is calculated directly from the VoDControlResponse parameter by converting the sample values from milliseconds to seconds.

The ServiceType of the MainStream instance must be equal to “VoD”.

8.7.2 KQI IPTV Video on Demand Control Performance [%]

The parameter KQI IPTV Video On Demand Control Performance describes the percentage of VoD control responses where the VoD control response time is less than or equal to a predefined threshold time.

8.7.2.1 Abstract Equation

$$\textit{KQI IPTV Video on Demand Control Performance}\ [\%] = \frac{\sum(\textit{VC where KPI IPTV VoD Control Response Time} \le \textit{VCT threshold})}{\textit{total number of VC}} \times 100,$$

$$\text{where}\ VC = \textit{VoD control responses}$$

$$\text{and}\ VCT = \textit{VoD control response time.}$$

8.7.3 Comments

This KPI covers the trick-play (play/pause) of a VoD media stream (pay-per-view/NPVR/time shift etc). Notice that FF/REW and pause are here excluded from the trick-play commands since they are more difficult to define in an unambiguous way.

8.8 IPTV Media Quality

8.8.1 KPI IPTV Media Quality [n]

The parameter KPI IPTV Media Quality is a value from an objective parametric multimedia quality model, which estimates Mean Opinion Score (MOS) expressed on a scale 1-5, according to ITU-T recommendation P.911.

[5] From an end-user perspective, the content is considered displayed on the screen when the complete picture has been drawn on the screen, not when it begins to be drawn on the screen.

8.8.1.1 Corresponding QoE Objective

TR-126 Video Frame Rate in STB (5.2.49). Video Impairment duration in STB (5.2.4), Audio Video Synchronization (6.2.2.19).

8.8.1.2 Abstract Equation

ITU-T Study Group 12 is working on a standardized parametric model for IPTV, with the working name P.NAMS. P.NAMS will probably be based on codec used, video resolution, packet loss, freezing etc. P.NAMS is recommended to be used when ready. The algorithm used in the model can be illustrated as:

TvQI [MOS_estimate] = Function {audio codec type and bit-rate, video codec type and bit-rate, transmission bit-rate, IP packet loss, video size, audio format, video format, audio and video delay difference and delay variation}[6]

8.8.1.3 Trigger Points

Not applicable.

8.8.1.4 Corresponding TR-135 Parameters

Object	STBService.{i}.Capabilities.ServiceMonitoring.
Parameter	HighLevelMetricNames

Object	STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.HighLevelMetricStats.{i}.
Parameter	MetricName Metric Enable

The parameter HighLevelMetricNames lists all quality metrics that the STB supports. If a metric produces several different scores (e.g. an audio, a video, and an audiovisual score), they will be explicitly named. Example (using "XYZ" as the name of the base metric): "XYZAudio,XYZVideo,XYZAudiovisual".

If a metric producing several different score is used, there will be several instances of the HighLevelMetricStats.{i} object. Each instance will carry the data for one particular type of score in the parameter Metric. The type of score will be given by the parameter MetricName, which must be a member of the list given by HighLevelMetricNames. The calculation of a specific metric can be enabled or disabled by the Enable parameter.

The Metric parameter is a comma-separated list, where each entry can be directly used to calculate the Media Quality KPI. Notice that the Metric is represented by an integer in the range [0,65535], and that a conversion to the actual range of the high level metric is probably needed.

[6] Note that most likely the final model will produce three separate scores, a video score, an audio score and a multimedia score.

8.8.2 KQI IPTV Aggregated Media Quality [%]

The parameter KQI IPTV Aggregated Media Quality describes the percentage of KPI IPTV Media Quality reports where the media quality is greater than or equal to a predefined media quality threshold.

8.8.2.1 Abstract Equation

$$KQI\ IPTV\ Aggregated\ Media\ Quality\ [\%] = \frac{\sum(KPI\ IPTV\ Media\ Quality\ \geq\ media\ quality\ threshold)}{total\ number\ of\ KPI\ IPTV\ Media\ Quality\ reports} \times 100$$

8.8.3 Comments

This KPI is not suitable for all media quality related usage.

8.9 IPTV IP Packet Loss Ratio

8.9.1 KPI IPTV Packet Loss Ratio [%]

The parameter KPI IPTV Packet Loss Ratio describes the percentage of IP packets that have been lost and could not be played out at the client. The Packet Loss Ratio is calculated as the ratio of IP packets that have not been received by the client in time and the total number of IP packets sent by the server.

8.9.1.1 Corresponding QoE Objective

IPTV Media Quality, TR-126 Loss Rate (6.3.1)

8.9.1.2 Abstract Equation

$$IPTV\ IP\ Packet\ Loss\ Ratio[\%] = \frac{Number\ of\ IP\ packets\ not\ received\ in\ time\ by\ client}{Total\ number\ of\ IP\ packets\ sent\ by\ server} \times 100$$

8.9.1.3 Trigger Points

Event from abstract equation	Trigger points from user's point of view	Technical description / protocol view
Number of IP packets not received in time by client	N/A	Number of IP packets that where not received in time or not received at all
Total number of IP packets sent by server	N/A	All IP packets that are transmitted for the first time, meaning that retransmissions are not included in this value

8.9.1.4 Corresponding TR-135 Parameters

Object	.STBService.{i}.ServiceMonitoring.MainStream.{i}.Sample.RTPStats.
Parameter	PacketsExpected PacketsReceived

The parameters are comma-separated lists, where each entry is the number of expected and received RTP packets a sample or sub-sample interval. For each sample interval, the KPI is calculated

$$IPTV\ IP\ Packet\ Loss\ Ratio\left[\%\right]=\left(1-\frac{PacketsReceived}{PacketsExpected}\right)\times 100.$$

Currently it is only possible to calculate the packet loss when media is transported over RTP. For MPEG2-TS over UDP it is not possible to calculate the packet loss ratio.

8.9.2 KQI IPTV Packet Loss Performance [%]

The parameter KQI IPTV Packet Loss Performance describes the percentage of KPI IPTV Packet Loss Ratio reports where the packet loss is less than or equal to a predefined threshold percentage.

8.9.2.1 Abstract Equation

$$KQI\ IPTV\ Packet\ Loss\ Performance\ [\%] = \frac{\sum(KPI\ IPTV\ Packet\ Loss\ Ratio\ \leq\ packet\ loss\ threshold)}{total\ number\ of\ KPI\ IPTV\ Packet\ Loss\ Ratio\ reports} \times 100$$

8.9.3 Comments

The KPI definition is included to support the media related KPI measurements. Dependent on the amount of IP packets per video frame, and dependent on whether or not these IP packets come from the same user, IP packet loss has a more or less good correlation with the video quality provided that the used video codec type and bit rate are known.

The packet loss should be measured close to the end-user, i.e. preferably after retransmission or FEC.

Depending on the length of the measurement period, other metrics can also be of interest for capturing the loss characteristics, e.g. the average length of consecutive packet losses ("Number of Loss Burst Packets") or the average number of consecutive packets received without losses ("Service Delay between Lost Packets"). For short measurement periods the loss characteristic is with reasonable accuracy captured by the packet loss performance metric variation over time.

Pertinent information is needed for service providers in order to qualify the quality of the IPTV service perceived by the client. Regarding IPTV service, temporal analysis of packet losses is important. Key information includes

- the consecutive number of lost packets,
- the time interval between losses,
- the duration of the perturbation (event loss).

TR-135 introduced the *Gmin* parameter: here *Gmin* is the minimum number of consecutive received packets after the end of an RTP Loss Event. A Loss Event is defined as a sequence of lost packets, possibly including islands of received packets. Each island consists of up to (*Gmin* – 1) received packets (a sequence of *Gmin* received packets terminates the Loss Event, and so is not an island).

The following example presents the way it should be considered for $Gmin = 3$.

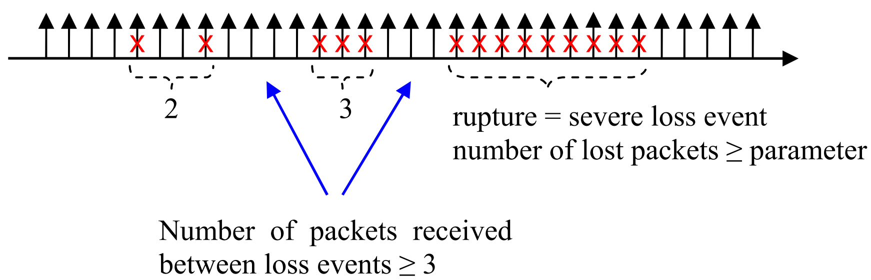


Figure 7 – Example of *Gmin* loss events for the case *Gmin* = 3

Regarding that perspective, two parameters are considered:
- A *Loss Event* is defined as a sequence of lost packets, possibly including islands of received packets where each island may consist of up to (*Gmin* – 1) received packets. A sequence of *Gmin* received packets terminates the Loss Event, and so is not an island.
- A *Severe Loss* is defined by the two parameters *SevereLossMinDistance* and *SevereLossMinLength*. Loss events are considered severe if they occur closer than SevereLossMinDistance or if they are longer than SevereLossMinLength.

Along with the IP Packet Loss Ratio, these parameters will help service providers to better understand how temporal characteristics of packet losses may impact IPTV QoE, and a way to measure it.

8.10 IPTV Channel Availability

8.10.1 KPI IPTV Channel Availability [%]

When delivering a set of TV channels to the end-user, the audio and video content might be missing even when an MPEG2-TS stream is detected by a passive monitoring system. The video artifact is usually called "black screen" and can be considered as one of the major troubles experienced by IPTV customers. It can be associated with a complete lack of audio. These two artifacts are considered annoying for an IPTV end-user.

Many channels are monitored somewhere in the network using either passive probes or signal analysis based robots. The channels are monitored over a defined/given period of time. If the monitoring is performed by probes or robots, the channels are preferably monitored in a roundrobin fashion. If the monitoring is performed by the STB, it is performed every time the end-user requests a TV channel. Each monitoring instance is called a “channel check”.

The KPI IPTV Channel Availability parameter describes the number of channel checks over time where the channel is available compared to the total number of checks. Unavailable channel is defined as complete lack of video (black screen) and/or complete lack of audio.

8.10.1.1 Corresponding QoE Objective

None applicable.

8.10.1.2 Abstract Equation

$$\textit{KPI IPTV Channel Availability } [\%] = \frac{\textit{number of channel checks where the TV channel is available}}{\textit{total number of channel checks for the TV channel}} \times 100$$

8.10.1.3 Trigger points

Event from abstract equation	**Trigger points from user’s point of view**	**Technical description / protocol view**
Number of channel checks	Start: The end-user requests a TV channel.	First IGMP message sent by the STB
Number of channel checks where the channel is available	Stop: The video image and audio are available on his TV set within a predefined time.	First multicast video I-frame and first audio frame received at the STB.
Number of channel checks where the channel is not available	Stop: The video is not displayed (black screen) and/or there is no audio available within a predefined time.	No video I-frame and/or no audio frame received at the STB before a predefined time.

8.10.1.4 Corresponding TR-135 Parameters

None applicable.

8.10.2 KQI IPTV Channel Availability [%]

The parameter KQI IPTV Channel Availability describes the number of monitored channels that are available for a predefined time compared to the total number of monitored TV channels.

8.10.2.1 Abstract Equation

$$KQI\ IPTV\ Channel\ Availability\ [\%] = \frac{\sum (TC\ where\ KPI\ IPTV\ Channel\ Availability\ \geq\ Availability\ threshold)}{Total\ number\ of\ TC\ monitored} \times 100,$$

where $TC = TV\ channels.$

8.10.3 Comments

The KPI IPTV Channel Availability for the video may be detected by using passive probes which may flag streams suffering a consecutive loss of I-frames, or by identifying a series of bytes within video frames which would indicate that a black screen is occurring. It may also be detected by using robots or probes implementing objective video signal measurements given the fact they are implementing reliable and efficient algorithms that are able to detect this problem.

The KPI IPTV Channel Availability for audio may be carried out using passive probes (placed within the aggregation network) that will detect if the Audio PID is missing within the MPEG2-TS streams. It can also be done by plugging a robot on the audio output of the decoding device which will check the presence of sound both on the left and right side when zapping over the full set of channels delivered to the end-user.

8.11 IPTV Video without Disturbance

8.11.1 KPI Video without Disturbance [%]

The parameter KPI Video without Disturbance describes the percentage of measurement periods where the video is displayed without any disturbances. By disturbances, the different video artifacts concerned are mainly macro-blocking, freezing or jerkiness. These problems may appear individually or combined.

8.11.1.1 Corresponding QoE Objective

None applicable.

8.11.1.2 Abstract Equation

$$KPI\ IPTV\ Video\ without\ Disturbance\ [\%] = \frac{number\ of\ video\ measurement\ periods\ without\ disturbance}{total\ number\ of\ video\ measurement\ periods} \times 100$$

8.11.1.3 Trigger Points

Event from abstract equation	Trigger points from user's point of view	Technical description / protocol view
Video measurement period	Start: The TV channel is being displayed to the end-	Start alt 1: Reception of video signal when measurement

	user and the measurement period is started Stop: The measurement period ends	period starts Start alt 2: Reception of first I-frame in measurement period Stop: End of measurement period
Video measurement period with disturbance	The video is impaired with blockiness or freezing	Alt 1: Analysis of the video signal to detect blockiness and freezing Alt 2: Analysis of transport stream to identify errors causing blockiness and freezing
Video measurement period without disturbance	The video is not impaired with blockiness or freezing	Alt 1: Analysis of the video signal to verify that it does not contain blockiness or freezing Alt 2: Analysis of transport stream to verify that there are no errors causing blockiness or freezing

8.11.1.4 Corresponding TR-135 Parameters

None applicable.

8.11.2 KQI IPTV Video without Disturbance [%]

Many channels are monitored somewhere in the network using either passive probes or signal analysis based robots. The KQI IPTV Video without Disturbance parameter describes the number of monitored channels that that meet the configured disturbances threshold compared with the total number of monitored TV channels.

8.11.2.1 Abstract Equation

$$KQI\ IPTV\ Video\ without\ Disturbance\ [\%] = \frac{\sum (TC\ where\ KPI\ IPTV\ Video\ without\ Disturbance\ \geq\ disturbance\ threshold)}{total\ number\ of\ TC\ monitored} \times 100,$$

where $TC\ =\ TV\ channels.$

8.11.3 Comments

This KPI can be detected in two ways:

Alternative 1:

The video impairments are detected using robots or probes implementing objective video signal based measurement algorithms capable of detecting macro blocking effects, freezing, or noise in the video. The audio impairments are detected using robots or probes implementing either parametric or objective audio measurement algorithms capable of detecting sound distortions or noise in the audio.

Alternative 2:
The video impairments are detected using passive probes which will detect streams suffering from severe packet losses which would indicate that the video is impaired with blockiness or freezing and sound issues.

NOTE – When measuring before the STB note that the packet loss might be corrected by FEC mechanisms. The residual packet loss in the STB can be less than the measured packet loss.

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