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QoS aspects of TCP-based video services like YouTube™

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

Introduction

There are a variety of popular TCP-based video services available on the internet, on which users can upload, view and share videos. These services use mainly Adobe® Flash® Video but also RealPlayer® and QuickTime® and lately HTML5 technology to display a wide variety of video content, including movie clips, TV clips, and music videos, as well as amateur content such as video blogging and short original videos.

These services have become very popular and have a major share of the internet traffic worldwide. Due to its high popularity in general and its use over mobile internet its availability and quality is of key interest of the provider of mobile internet access, which makes the services a matter for benchmarking. The down-stream scenario, the probability to access and see a desired video and the quality of the video is the subject of measurement method laid out in the present document.

Any video content is accessed via a link that is provided by the service on a web page. The actual linked videos need to be qualified however e.g. YouTube™ provides different quality profiles of the same video content e.g. a music video clip. The individual quality profiles can differ in resolution (e.g. 240p, 360p, 480p, HD720p, HD1080p), in the data-rate and other aspects. Since these differences of clips have an impact on their size and thus on the reproduction speed and quality, a fair comparison can only be provided if actually the same clips are streamed over different networks. On the other hand the clips not need to come physically from the same server since mobile operators employ proxies in order to move the content closer to their subscriber and the downlink bandwidth is often controlled primarily by the video service. Therefore the clips need to be streamed from the actual live network and may not be streamed from a dedicated server.

For cases in which the video content is compressed during the transfer by a proxy hence the content arriving at the subscriber is not identical, the compression ratio may be indicated to show that possible advantages in performance are achieved by reducing the amount of data to be transferred. Whether this enhancement was achieved at the cost of the general quality of the content could be determined by an objective video quality assessment.

The TCP-based videos can be received either on Smartphone or a PC connected via mobile network to the internet. For the Smartphone the way the content is provided can differ significantly with the type and the OS the phone is using. In the present document content delivery for special Apps, RealPlayer® and QuickTime® is not taken into consideration but only the streaming over TCP as e.g. used by YouTube™ with a Browser on a PC or Smartphone with the respective player.

1 Scope

The present document focuses on Quality of Service (QoS) measurements for TCP-based video services where downloading and viewing takes place in parallel. In principle the presented measurement approach can be used for all video services, where the video is embedded in a HTML context as of video on demand services like e.g. YouTube™. Similar applications are also available on social networks.

In the following, QoS parameters to be used for such video service measurements are presented. The underlying procedure consists of two phases: first requesting a control script containing among other information a link to the content, and second, requesting this content. In the present document, YouTube™ serves as the default example but the described QoS parameters can easily be applied to other TCP-based video services.

Furthermore, this report also offers practical guidance for measurement execution and evaluation of HTTP streaming QoS measurement.

The present document covers the video request and playout of the video. Other services offered by content providers such as e.g. uploading video or managing the private account are not covered.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 102 250-2: "Speech and multimedia Transmission Quality (STQ); QoS aspects for popular services in mobile networks; Part 2: Definition of Quality of Service parameters and their computation".

[i.2] ETSI TS 102 250-5: "Speech and multimedia Transmission Quality (STQ); QoS aspects for popular services in mobile networks; Part 5: Definition of typical measurement profiles".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CPU	Central Processing Unit
DNS	Domain Name System
FLV	Flash® Video
FTP	File Transfer Protocol

GPU	Graphics Processing Unit
HDD	Hard Disk Drive
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IP	Internet Protocol
LAN	Local Area Network
NDIS	Network Driver Interface Specification
OS	Operating System
PC	Personal Computer
PEC	Performance Enhancement Client
QoS	Quality of Service
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
SYN	TCP synchronise flag
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
URL	Uniform Resource Locator
WLAN	Wireless Local Area Network

4 Quality of Service measurements for TCP-based video services like YouTube™

Many TCP-based video services, like e.g. the YouTube™ video service, provide videos in several resolutions and qualities. For some video services the client can choose the resolution and quality of the video playback manually. On the other hand, several mobile clients often allow only lower resolutions (delivered in lower bandwidth). Usually, videos are streamed in proprietary Flash® format (FLV) over TCP. In addition, for very large videos or client devices not supporting Flash® other formats are supported as well, e.g. 3GP video down-stream via RTP/UDP for RealPlayer® on Symbian OS™.

4.1 Phases of TCP-based video services

Most TCP-based video services, like the YouTube™ video service, are comprised of several phases which are mainly the set-up of a HTML context including downloading the control script for the multimedia playout entity (in the following: "player") and the down-stream of the video itself.

Figure 1 shows typical phases of TCP-based video services, like YouTube™.

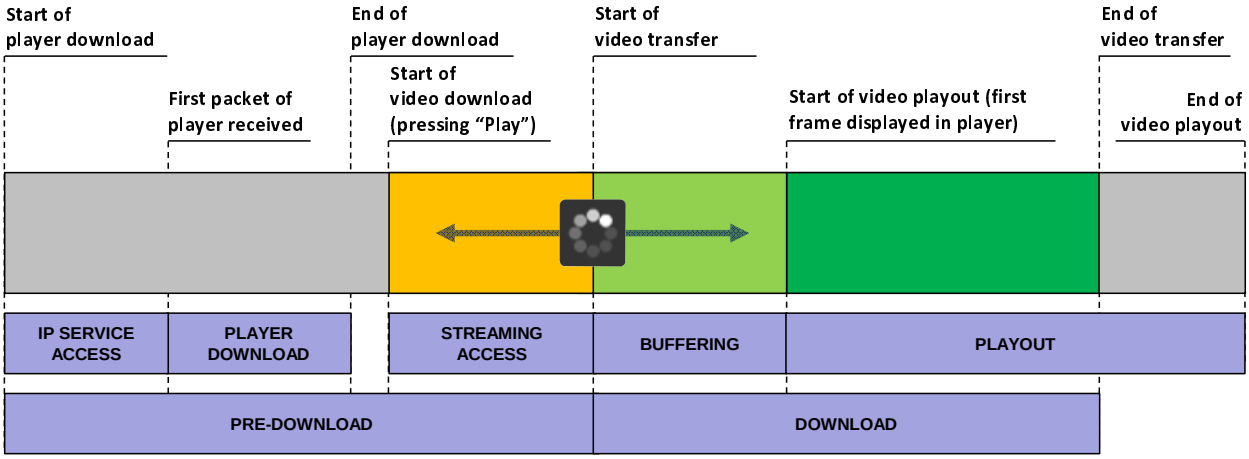

Figure 1: Typical phases of TCP-based video services

In principle the video service can be divided into the setup of the context until the player is ready to play and the download and playout of the video.

The setup of the context until the player is ready to play can be divided into two phases, the "IP service access" phase and the "player download" phase.

The "IP service access" phase starts when the HTML context and the player configuration download are requested. It ends upon receipt of the first data byte containing HTML content, starting the player download phase.

NOTE: The initial DNS request sent when e. g. the YouTube™ URL is opened is not considered to be part of the "IP service access" phase. Thus, the quality of service for the initial DNS resolution for the HTML context and the player configuration download is not covered by the QoS parameters defined in the present document for the "IP service access" phase.

The "IP service access" phase is followed by downloading the HTML context information and the player configuration script (in case of Flash® Player). It contains potential surrounding HTML based information (YouTube™ site), which can be the original YouTube™ site with an embedded player (YouTube™ in a browser window), or the player application without any visible HTML context (YouTube™ App or Flash® Player in an empty HTML context). The last step of the context setup is the download of the player configuration script. The entire download phase is called simplified "player download". At the point the context and the configuration is downloaded completely, the player is "ready to play".

The "streaming access" phase is started by pressing the "Play" button (or in case of "AutoPlay" with the event "Ready To Play" that is then equivalent to requesting the video) and ends with receiving the first video packet over TCP or RTP. This phase could be very interesting if there are proxies between the user and the content server, thus making DNS resolution and other events an influential factor.

In a simple case, during "streaming access" phase there will be only one GET (in case of a requested TCP stream) or a RTSP DESCRIBE (in case of a requested RTP stream) request for the video, followed immediately by the 200 OK message and the payload packets for FLV (TCP) or 3GP (RTP) video. In a more complex case, there may either be several ranged GET requests or it may happen that after the first GET request there will be several redirects (because of proxies) and several more resolving of DNS, etc. so this phase can be much longer. Basically, QoS parameters related to this phase allow concluding how close the network is to the content server for the measured video. Even if a preferred server (URL) is given and firstly requested, the actual approached location of the clip may differ and lead to a redirection to a closer or more appropriate server and DNS has to be contacted again.

In case of RTSP, an RTSP link is embedded in the HTML context. After receiving the final URL or the video, the video can be streamed/downloaded (Ready to Play).

Upon receiving the first video packet, the "buffering" phase commences. While the "download" phase will end with the last received video packet, the "buffering" phase ends in the moment the video playout actually starts. QoS parameters related to this phase allow estimating the initial buffer size for the measured video and current Internet connection type (e.g. DialUp, NDIS, WLAN, LAN).

The "IP service access", the "player download" and the "streaming access" phases jointly constitute the "pre-download" phase. The "buffering" and the remaining video content transfer constitute the "download" phase.

As soon as playout starts, the "playout" phase commences. This phase overlaps with the "download" phase and represents the full playout time for the video. Depending on the configuration the full video can be displayed or video playout can be cut short when video download is complete.

During the "playout" phase the "freezes" of the video display and "video skips" are detected.

4.2 QoS aspects of TCP-based video services

When looking at impairments of the video playout, this clause focuses on objectively measurable impairments, such as:

- failures to start;
- video freezes;
- video skips; or
- failures to download completely.

It may be that further subjective impairments exist, which limit comparability of QoS parameters obtained in different setups. Such subjective impairments can e.g. be downscaling of video image quality or frame-rate.

4.2.1 Video freezes and - skips

Freezing events are when the video playout stops (freezes), it is mainly caused by a buffer under-run. The video pauses until the re-buffering is complete. After that, the video continues. There is no video information lost. This is the common case for YouTube™ using Flash® Player.

Skip events are when playout is not continuous, which means that parts of the video content are not displayed or re-displayed, i.e. the playout jumps to a future or past point in time. A possible reason for this can be player misbehaviour or network outage in combination with live streams. When a skip occurs, there is usually no visible re-buffering information on the screen.

4.3 QoS parameters for TCP-based video services

In this clause, a set of QoS parameters based and expanding on the streaming QoS parameters as defined in [i.1] is proposed for measuring TCP-based video services.

Table 1 gives an overview of the proposed QoS parameters and provides a mapping of these parameters to the phases introduced in clause 4.1. Furthermore, a parameter type is assigned for each QoS parameter in order to determine the calculation method to be used for the respective parameter.

Table 1: Overview of QoS parameters and mapping to typical phases of TCP-based video services

Related Phase(s)	QoS parameter name	QoS parameter type
IP service access	Player IP Service Access Failure Ratio	Failure Ratio
IP service access	Player IP Service Access Time	Duration
Player download	Player Download Cut-off Ratio	Cut-off Ratio
Player download	Player Download Time	Duration
IP service access, Player download	Player Session Failure Ratio	Failure Ratio
IP service access, Player download	Player Session Time	Duration
Streaming access	Video IP Service Access Failure Ratio	Failure Ratio
Streaming access	Video IP Service Access Time	Duration
Buffering	Video Reproduction Start Failure Ratio	Failure Ratio
Buffering	Video Reproduction Start Delay	Duration
Streaming access, Buffering	Video Play Start Failure Ratio	Failure Ratio
Streaming access, Buffering	Video Play Start Time	Duration
Pre-download	IP Service Access Failure Ratio	Failure Ratio
Pre-download	IP Service Access Time	Duration
Streaming access, Buffering, Playout	Video Session Cut-off Ratio	Cut-off Ratio
Streaming access, Buffering, Playout	Video Session Time	Duration
Streaming access, Buffering, Playout	Impairment Free Video Session Ratio	Calculation
Download	Video Expected Size	Size
Download	Video Downloaded Size	Size
Download	Video Compression Ratio	Calculation
Download	Video Transfer Cut-off Ratio	Cut-off Ratio
Download	Video Transfer Time	Duration
Download	Video Mean User Data Rate	Calculation
Playout	Video Playout Cut-off Ratio	Cut-off Ratio
Playout	Video Playout Cut-off Time	Duration
Playout	Video Expected Duration	Duration
Playout	Video Playout Duration	Duration
Playout	Video Freeze Occurrences	Count
Playout	Accumulated Video Freezing Duration	Calculation
Playout	Video Skip Occurrences	Count
Playout	Accumulated Video Skips Duration	Calculation
Playout	Video Maximum Freezing Duration	Calculation
Playout	Video Freezing Impairment Ratio	Failure Ratio
Playout	Video Freezing Time Proportion	Calculation
Whole session	End-to-End Session Failure Ratio	Failure Ratio

Within table 1, the following QoS parameter types are defined:

- Calculation
- Count
- Duration
- Size
- Cut-off Ratio; and
- Failure Ratio

The type "Calculation" is assigned to QoS parameters getting calculated based on other QoS parameters or other measurable qualities within the same single measurement, e.g. durations of single freezes or single skips.

The type "Count" is assigned to QoS parameters where the QoS parameter is calculated by counting occurrences of a certain event during a time period between a start trigger point and a stop trigger point, both observed during a single measurement. The following equations define the abstract equation to be used to calculate such a parameter:

$$\text{Count} = \sum_{i=\text{start trigger}}^{\text{stop trigger}} occurrence(t_i, event)$$

$$\text{occurrence}(t, event) = \begin{cases} 1, \text{if event occurs at time } t \\ 0, \text{else} \end{cases}$$

The type "Duration" is assigned to QoS parameters where the QoS parameter represents an expected or an actual time period between a start trigger point and a stop trigger point, both observed during a single measurement. The following equation defines the abstract equation to be used to calculate such a parameter:

$$\text{Duration}\,[s] = \left(t_{\text{stop trigger}} - t_{\text{start trigger}}\right)[s]$$

The type "Size" is assigned to QoS parameters where the QoS parameter is determined by the size of a quantity, e.g. the expected or the actual size of a video.

The type "{Failure | Cut-off} Ratio" is assigned to QoS parameters representing a failure or Cut-off ratio. The following equation defines the abstract equation to be used to calculate such a QoS parameter. Here, the term "unsuccessful attempt" should be understood in the way that, during a single measurement, the stop trigger point of the QoS parameter has not been observed within a given time after having observed the respective start trigger point.

$$\{\text{Failure}\,|\,\text{Cut-off}\}\,\text{Ratio}\,[\%] = \frac{\text{unsuccessful attempts}}{\text{all attempts}} \times 100$$

For the computation of the QoS parameter with type "Calculation", "Count" or "Size", further information is given for each QoS parameter within the following clauses, if applicable.

Table 2 gives an overview of the trigger points used for the QoS parameter definition. For each trigger point, an ID is introduced. This ID will later be used as a reference within the QoS parameter definitions.