Technical White Paper on Mobile Bearer Network Requirements for Mobile Video Services

Joint Release by Huawei mLab and iLab

Introduction

This document defines the Mobile U-vMOS and describes the relationships between KQIs and KPIs (such as the access bandwidth, RTT, and PLR). It also illustrates the baseline requirements on E2E KPIs for the mobile bearer network as well as the suggestions on these baselines.

1 Mobile U-vMOS Overview

U-vMOS (User, Unified, Ubiquitous-Mean Opinion Score for Video) is a standard that Huawei develops to measure video experience, which covers a wide array of video services on mobile terminals, PCs, and TVs, including the traditional entertainment video services (VOD and BTV), video surveillance, and video calls.

Based on human factors engineering tests and user survey, Huawei worked out the three key factors that may affect video experience: video quality (sQuality), interactive experience (sInteraction), and viewing experience (sView).

Regarding on-demand videos played on small screens, mLab joined hands with University of Oxford and Peking University to conduct qualitative researches on consumers. It is found that the three key network elements in video MOS are video definition, initial buffering delay, and video freeze duration, based on which the Mobile U-vMOS standard is introduced. As defined in Mobile U-vMOS, the interactive experience at video playback startup is determined by the initial buffering delay (sLoading) and the interactive experience during video playback is determined by the video freeze duration (sStalling). Therefore, Mobile U-vMOS is a subset of the U-vMOS in mobile small-screen scenarios.

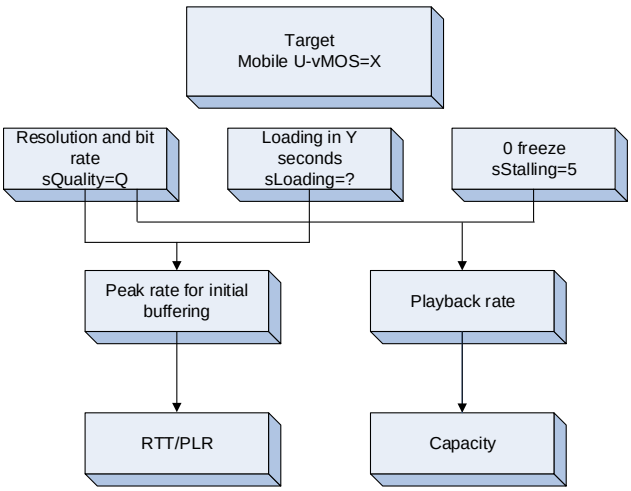
$$Mobile\ U-vMOS = f(sQuality, sLoading, sStalling)$$

2 Methodology of Network Planning Based on Mobile U-vMOS

This document discusses the OTT VOD scenario which is the mainstream scenario for mobile videos. Huawei iLab and mLab have conducted a lot of researches on how to plan networks based on Mobile U-vMOS.

When it comes to the three elements of Mobile U-vMOS in OTT VOD services, the typical sQuality values (including the resolution and bit rate) and the sStalling score as 5 (no freeze during video playback) are used as the video experience targets. After the Mobile U-vMOS score is obtained based on live network evaluation and research, the initial buffering score (sLoading) can be determined, which is a reference for the initial buffering delay of live network videos. The initial buffering delay is an input parameter for network KPI calculation.

Figure 2-1 Basic process of network planning based on Mobile U-vMOS

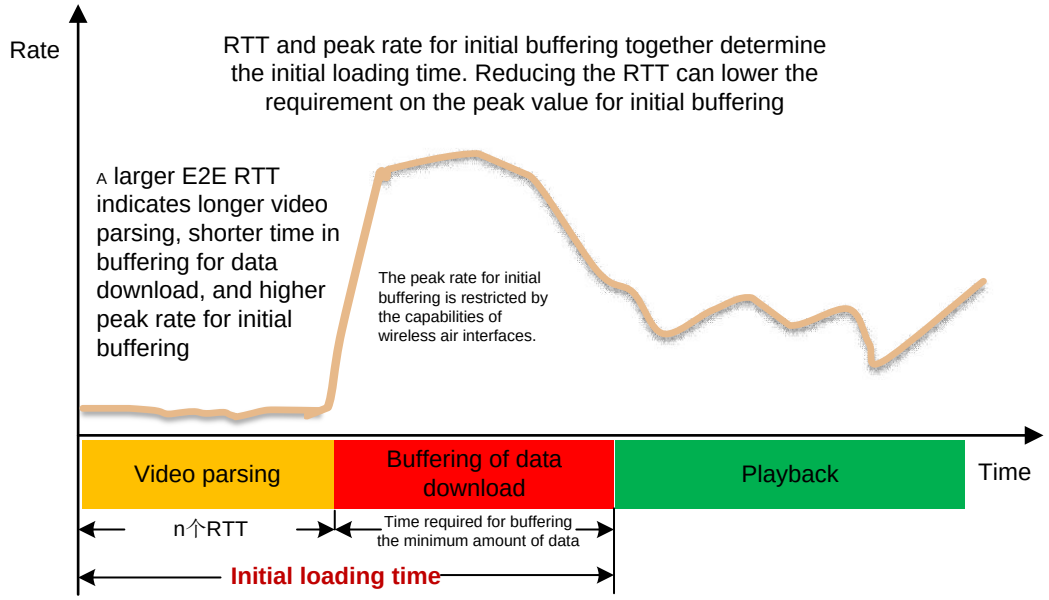


The initial buffering of OTT videos is a burst process where the amount of data proportional to the average bit rate needs to be downloaded within a specified period. sLoading corresponds to the initial buffering

delay, which determines the peak rate for initial buffering (peak TCP throughput of initial buffering) required when video playback is launched. This can further be used as an input for the calculation of network KPIs, guiding MBB bearer network architecture planning based on Mobile U-vMOS.

The MBB network KPIs planned in this method can meet the requirements for the peak rate for initial buffering.

Figure 2-2 Typical initial loading process of OTT videos



Following the buffering stage, there comes the playback stage where the download rate (throughput) at any time cannot be lower than a multiple of the average bit rate. This ensures no video freeze during the whole playback process. Such a multiple is the requirement for the playback rate (continuous throughput). On an MBB network, each concurrent video user must meet the required playback rate during busy hours. This playback rate, together with other service parameters, can be weighed to obtain the target rate for each user, which guides the MBB network capacity planning for video experience guarantee.

The playback rate requirement also maps to network KPIs. As the peak rate for initial buffering cannot be lower than the playback rate, the MBB network KPIs are planned based on the peak rate for initial buffering.

3 E2E KPIs for MBB Networks

This chapter describes how to map the Mobile U-vMOS target to E2E KPIs of MBB networks.

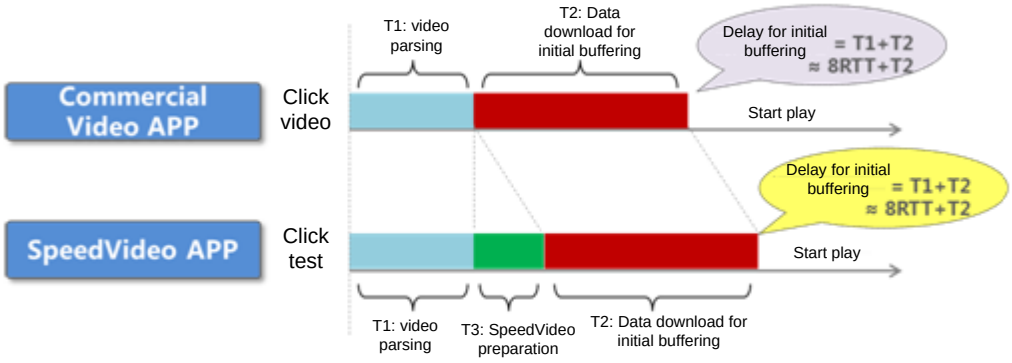
As shown in Figure 2, the initial loading stage can be divided into video parsing and buffering for data download. The duration for video parsing is relevant to the OTT platform and terminal design principles. Typically, this duration is a multiple of RTT. The duration of the buffering for data download is relevant to the minimum buffering data amount and peak rate for initial buffering.

Given that the target initial loading time (such as 1s) is determined, a larger E2E RTT indicates longer video parsing, shorter time in buffering for data download, and higher peak rate for initial buffering. However, the peak rate for initial buffering is restricted by the capabilities of wireless air interfaces. Therefore, E2E RTT planning is closely related to the capabilities of wireless air interfaces. Reducing E2E

RTT can lower the bandwidth requirements for wireless air interfaces. On the contrary, a large E2E RTT poses challenges to the bandwidth of wireless air interfaces.

E2E RTT and the peak rate for initial buffering together determine the initial loading time.

Figure 3-1 SpeedVideo's initial buffering process



As a higher rate of a wireless air interface leads to less restrictive requirements on the upper threshold of E2E delay, in case of insufficient air interfaces, network planning or optimization is required to reduce E2E delay in order to lower the requirement on the peak rate for initial buffering. An example assumes that:

- The initial buffering delay is *t*.
- The minimum data amount for buffering is *Data*.
- The theoretical maximum peak rate for initial buffering of air interfaces is *P*.
- The playback rate determined by the video source bit rate is *H*.
- The video parsing requires *x* RTTs, (T1 shown in Figure 3).
- TCP slow start requires *s* RTTs.
- The amount of data to be downloaded during TCP slow start is *Ds*.

Then, the time for the buffering phase for data download is *t*-*x**RTT. The calculation formula for *Thrp* to reach the peak throughput at the stable stage is as follows:

$$Thrp = \frac{Data - Ds}{t - (x + s) * RTT}$$

Here, $Thrp \le P$.

In addition, the peak rate for initial buffering cannot be lower than the playback rate.

$$Thrp \ge H$$

Table 3-1 assumes that the Mobile U-vMOS score is 4, the bit rate is 3 Mbit/s for 1080p videos, and the initial buffering delay is 1s. Based on analysis on the mainstream mobile video clients like YouTube and Youku, mLab and iLab take the data amount for initial buffering as 4s and video playback protocol as HTTP adaptive streaming (HAS) to get the requirements on the peak rate for initial buffering corresponding to varying E2E RTTs.

Table 3-1 Peak rates for initial buffering corresponding to varying E2E RTTs

E2E RTT	Peak Rate for Initial Buffering
10 ms	15 Mbit/s
20 ms	20 Mbit/s
30 ms	30 Mbit/s
40 ms	85 Mbit/s
ms	> 150 Mbit/s

Considering that the current E2E delay of mobile services as lower than 20 ms is a restrictive requirement and so as the peak rate (single TCP throughput) of over 85 Mbit/s for each mobile user in playing 3 Mbit/s videos, we take RTT = 30 ms. The peak rate for initial buffering as 30 Mbit/s for each mobile user is used as the baseline requirement for Mobile U-vMOS of 4.

With the baseline requirements for E2E RTT and peak rate for initial buffering obtained, we can calculate the threshold for the packet loss rate based on the TCP throughput calculation formula.

$$T \le \frac{MSS}{RTT * \sqrt{\rho}} \Rightarrow \rho \le (\frac{MSS}{RTT * T})^2$$

Here, p is the packet loss rate (PLR), *MSS* is the minimum transmission unit, and T is the TCP throughput for a single user.

Given that the peak rate is 30 Mbit/s and the RTT is 30 ms, the E2E PLR requirement is $\le 1.7 \times 10^{-4}$.

Table 3-2 lists the mobile network E2E KPI requirements corresponding to the typical bit rates and initial loading times for videos at varying resolutions, with the data amount of initial buffering as 4s and the video playback protocol as HAS.

Table 3-2 Typical E2E KPI requirements corresponding to varying Mobile U-vMOS scores

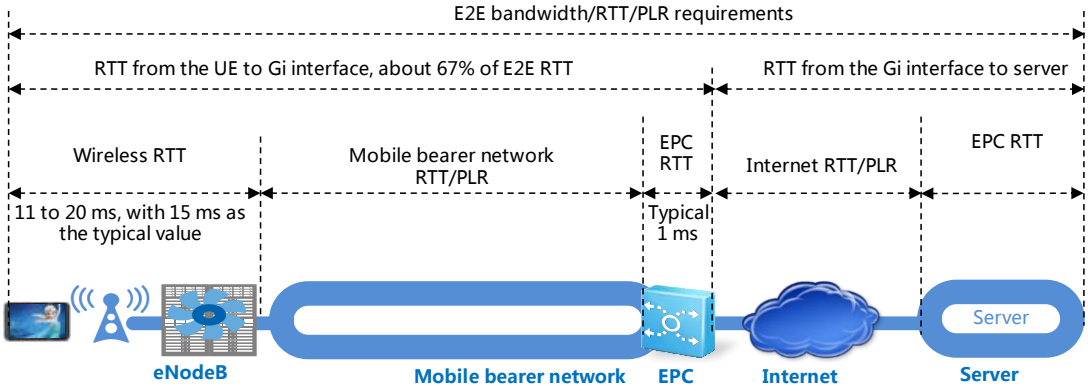
Typical U-vMOS Value	Initial Buffering Latency (s)	Video Source		Requirements for E2E Network KPIs			
		Resolution	Typical Bit Rate (Mbps)	Playback Rate (Mbps)	Peak Rate for Initial Buffering	RTT (ms)	PLR Threshold
3	2	480P	0.7	0.9	4.6	80	1.0E-03
3.3	2	720P	1.5	2.0	8.8	70	3.6E-04
3.5	1.5	720P	1.5	2.0	18.9	60	1.1E-04
3.8	1.5	1080P	3	3.9	19.7	45	1.7E-04
4	1	1080P	3	3.9	29.7	30	1.7E-04
4.2	1	2K	6	7.8	65.3	30	3.6E-05
4.5	1	4K	13.5	17.6	96.7	20	3.6E-05

For calculation details about Mobile U-vMOS and network KPI requirements, go to http://mlab.huawei.com or http://speedvideo.huawei.com to download the calculation tools.

4 E2E KPIs for the Mobile Bearer Network

Figure 4-1 shows the E2E networking of the mobile video service, spanning across across wireless, mobile bearer network, EPC, Gi interface, and server. After E2E KPI requirements for the mobile network are obtained, we can use the segment-by-segment method to analyze the target KPI values for the mobile bearer network: First, based on lab tests and live-network data, we can obtain the network KPI range and recommended values from wireless air interfaces and EPC to the content source. Then, we can obtain the recommended KPI values for the mobile bearer network.

Figure 4-1 E2E networking for the mobile video service



Based on the global RTT data in 2015 H1 from mLab, for 4G networks, the average RTT from the terminal to the Gi interface (hereinafter referred to as RTT $_{below\ Gi\ interface}$) accounts for over 67% of the E2E RTT. Although the RTT $_{below\ Gi\ interface}$ on the 4G network is decreased compared to the 3G network, it is still a major part of the E2E RTT. The following uses the typical proportion of RTT $_{below\ Gi\ interface}$ to E2E RTT as 67%.

$$RTT_{belowGi\,interface} \approx 0.67 * RTT_{E2E}$$

RTT $_{\text{below Gi interface}}$ consists of the RTT $_{\text{air interface}}$, RTT $_{\text{mobile bearer network}}$, and RTT $_{\text{EPC}}$.

$$RTT_{belowGi\,interface} = RTT_{air\,interface} + RTT_{mobilebearernetwork} + RTT_{EPC}$$

RTT $_{air\ interface}$: When the wireless signals are good and the network is lightly loaded, RTT $_{air\ interface}$ ranges from 11 ms to 20 ms based on the mLab and iLab tests and live network measurement. Here, the average value of 15 ms is used for analysis.

RTT $_{EPC}$: The average unidirectional delay of 0.5 ms and RTT of 1 ms are used for analysis on the forwarding of common packets.

RTT $_{\text{mobile bearer network}}$ is obtained by subtracting RTT $_{\text{air interface}}$ and RTT $_{\text{EPC}}$ from RTT $_{\text{below Gi interface}}$.

Regarding the E2E KPI requirements based on the typical Mobile U-vMOS value, a higher U-vMOS score indicates a lower tolerance on PLR. When the U-vMOS score exceeds 4.2, the acceptable E2E PLR is 10^{-5}. E2E PLR may involve the packet loss from the Gi interface to the server, the packet loss on the wireless access segment, and the packet loss on the mobile bearer network. To ensure good video experience, Huawei recommends the mobile bearer network PLR of below 1.0E-5 based on live network experience data and lab test results.

Table 4-1 lists the recommended KPI values for the mobile bearer network corresponding to the typical bit rates and initial loading times for videos at varying resolutions, with the data amount of initial buffering as 4s and the video playback protocol as HAS.

Table 4-1 Recommended KPI values for the mobile bearer network based on typical Mobile U-vMOS values

Typical U-vMOS Value	Initial Buffering Latency (s)	Video Source		Requirements for E2E Network KPIs				移动承载网KPI建议	
		Resolution	Typical Bit Rate	Playback Rate (Mbps)	Peak Rate for Initial Buffering	RTT (ms)	PLR Threshold	RTT建议 (ms)	丢包率建议
3	2	480P	0.7	0.9	4.6	80	1.0E-03	38	1.0E-05
3.3	2	720P	1.5	2.0	8.8	70	3.6E-04	31	1.0E-05
3.5	1.5	720P	1.5	2.0	18.9	60	1.1E-04	24	1.0E-05
3.8	1.5	1080P	3	3.9	19.7	45	1.7E-04	14	1.0E-05
4	1	1080P	3	3.9	29.7	30	1.7E-04	4	1.0E-05
4.2	1	2K	6	7.8	65.3	30	3.6E-05	4	1.0E-05
4.5	1	4K	13.5	17.6	96.7	20	3.6E-05	2	1.0E-05

CAUTION

Mobile video service experience guarantee is a joint work among terminal, wireless, mobile bearer network, core network, and server. Data in Table 4-1 comes from the lab test results and typical experience values of the live network, which is the recommended KPIs for mobile bearer networks. For the mobile video experience evaluation of the live network, refer to the local video playback mechanism and E2E network conditions.

Attachment A: References

1. *Huawei U-VMOS Video Experience Standard Technical White Paper V1.1*
2. mLAB's *E2E_RTT Insights Report (2015H1)*
3. iLab's *OTT Video Initial Loading Technical White Paper*