

QoE Evaluation for CMAF-based Low-latency Streaming

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This report shows how to evaluate the quality of experience (QoE) for CMAF-based low-latency streaming application. These models (per-chunk and per-segment) are re-formulated based on two models Yin *et al.* [(1)] and Yi *et al.* [(2)].

To evaluate the CMAF-based adaptive bitrate (ABR) schemes, we consider five essential metrics: bitrate selected, bitrate switches, rebuffering time, live latency, and playback speed. The re-formulated QoE models can be expressed as:

1 Per-chunk QoE

$$QoE = \sum_{s=1}^S \sum_{c=1}^C (\alpha R_{s,c} - \beta E_{s,c} - \gamma L_{s,c} - \sigma |1 - P_{s,c}|) - \sum_{s=1}^{S-1} \mu |R_{s+1} - R_s|. \quad (1)$$

2 Per-segment QoE

$$QoE = \sum_{s=1}^S (\alpha R_s - \beta E_s - \gamma L_s - \sigma |1 - P_s|) - \sum_{s=1}^{S-1} \mu |R_{s+1} - R_s|. \quad (2)$$

We note that the playback speed is usually: (i) Normal: 1x, (ii) Fast: e.g., 1.05x, or (iii) Slow: e.g., 0.95x. Thus, if the playback speed is normal then playback speed penalty will be 0. Otherwise, playback speed penalty should be set to the minimum encoding bitrate level (e.g., 200 Kbps).

3 Evaluation

First, the player status should be logged at every chunk boundary (e.g, per-frame ≈ 33 ms). Then, the QoE can be computed offline using either (1) or (2).

Second, to evaluate the ABR schemes in a fair way, the encoding parameters should be fixed. Then, the QoE should be computed for each network trace, and the final QoE score is the average among all network traces. The ABR scheme that achieves the highest final QoE will be the winner.

References

- [1] X. Yin, A. Jindal, V. Sekar, and B. Sinopoli, “A control-theoretic approach for dynamic adaptive video streaming over http,” in *Proceedings of the 2015 ACM Conference on Special Interest Group on Data Communication*, pp. 325–338, 2015.

Table 1: List of notations for QoE function.

Notation	Meaning
c	A chunk of a segment s
s	A segment
$R_{s,c}$	Chunk bitrate (Kbps)
R_s	Segment bitrate (Kbps)
E	Rebuffering time (seconds)
L	Live latency (seconds)
P	Playback speed (e.g., 0.95, 1.0, 1.05)
S	Total number of segments
C	Total number of chunks
α	Bitrate reward factor (= chunk duration [e.g., 0.033 seconds] in (1) or segment duration [e.g., 1 seconds] in (2))
β	Rebuffering penalty factor (= maximum encoding bitrate level [e.g., 1000 Kbps])
γ	Live latency penalty factor (if $L \leq 1.1$ seconds then = 0.005, otherwise = 0.01)
σ	Playback speed penalty factor (= minimum encoding bitrate level [e.g., 200 Kbps])
μ	Bitrate switch penalty factor (= 0.02 seconds or = 1 second if the bitrate switch is too important)

- [2] G. Yi, D. Yang, A. Bentaleb, W. Li, Y. Li, K. Zheng, J. Liu, W. T. Ooi, and Y. Cui, “The acm multimedia 2019 live video streaming grand challenge,” in *Proceedings of the 27th ACM International Conference on Multimedia*, pp. 2622–2626, 2019.