Performance Estimation of Encrypted Video Streaming in Light of End-User Playback-Related Interactions Based on Machine Learning

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Motivation

- Widespread use of traffic encryption by Over The Top (OTT) providers such as YouTube, Netflix, Hulu, etc.
- Challenge of estimating HTTP adaptive video streaming Quality of Experience (QoE) and Key Performance Indicators (KPI)
  - Proposals of various machine learning (ML) techniques [1],
  - Focus is for the most part on videos without any user interactions with the video player.
- In a realistic environment, users commonly invoke some form of interaction while watching videos [2].

Research Methodology

- The main objective of this research is to specify an approach for in-network estimation of QoE-related KPIs of encrypted video sessions containing playback-related user interactions and viewed on mobile devices.

1) Propose a model of playback-related user interactions for adaptive video streaming services on mobile devices.

2) Implement a generic framework which includes automated data collection with an option of user behavior simulation, and training of ML models.

3) Derive models for in-network estimation of QoE-related KPIs for adaptive video streaming services.

Playback-Related User Interactions

- During the interaction-monitoring campaign in May and June of 2021, events from 816 video sessions were collected.
- Approximately 87% of video sessions were abruptly terminated by the user.

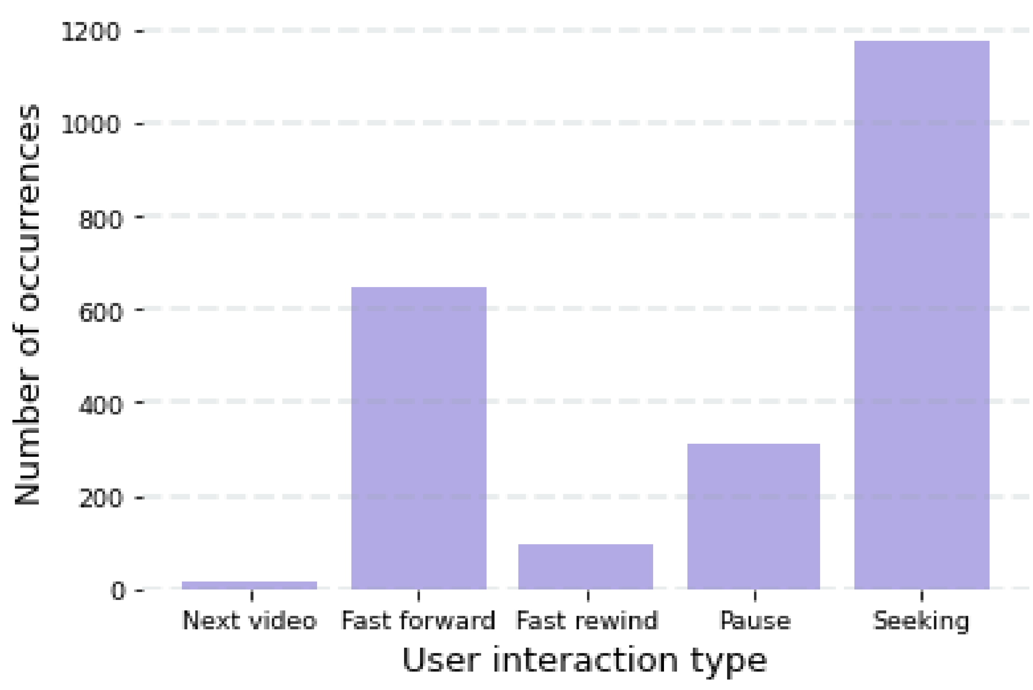

Figure 1. Most performed user interactions during the interaction-monitoring campaign

Interactions in Quality Estimation Process

- Results from initial studies regarding the impact of user interactions on ML classification accuracy, motivate the need to systematically include data corresponding to various interaction scenarios when training QoE-related KPI classification models [3].

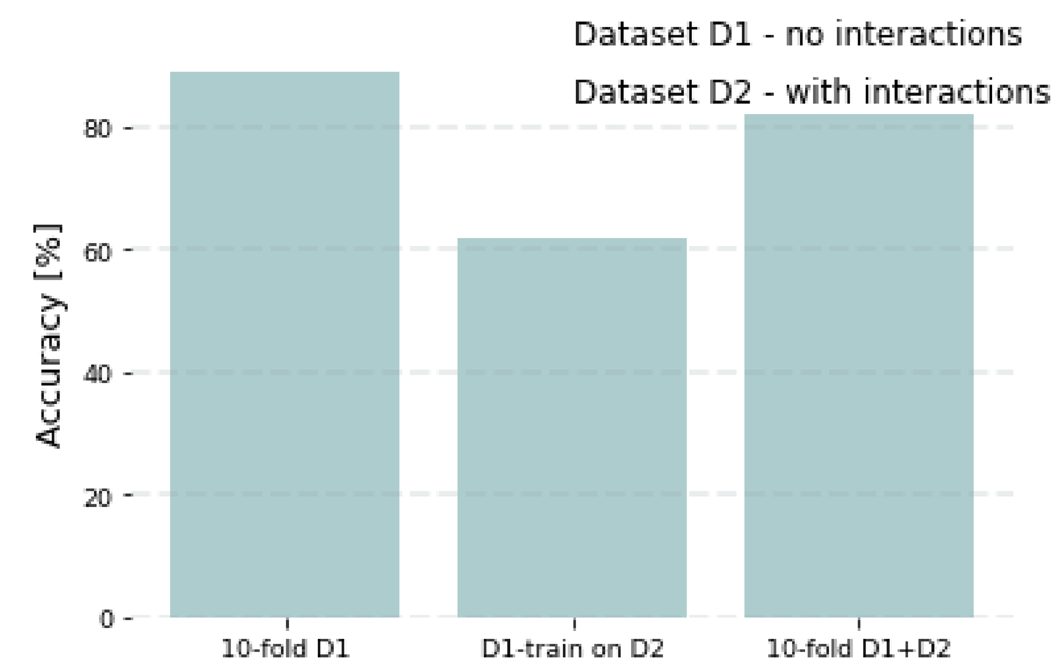

Figure 2. Accuracy of Random Forest models for classifying average video bitrate in 3 classes

- Research has been conducted to investigate which user interactions should be included in the process of data collection and training of ML models [4] (**N** – no interactions, **P** – pause, **S** – seek, **A** – abandonment).

Table 1. Accuracy of Random Forest models for classifying longest played resolution in 3 classes

	Trained on x, validated on y							
	x={N}	x={N, S}	x={N, A}	x={N, P}	x={N, S, A}	x={N, S, P}	x={N, A, P}	x*
y = x	79%	74%	72%	75%	73%	74%	74%	74%
y = {N, P, A, S}\x	68%	67%	68%	70%	59%	66%	74%	-

Conclusion

- Research results indicate that the inclusion of user playback-related interactions in the ML model training process increase the performance of in-network QoE-related KPI estimation models in the wild as compared to models trained on data excluding interactions.

References

[1] Orsolic, Irena, et al. "A Machine Learning Approach to Classifying YouTube QoE Based on Encrypted Network Traffic." *Multimedia tools and applications* 76, no. 21 (2017): 22267-22301.
[2] Moldovan, Christian, et al. "User Behavior and Engagement of a Mobile Video Streaming User From Crowdsourced Measurements." In *2019 QoMEX*, pp. 1-3. IEEE, 2019.
[3] Bartolec, Ivan, et al. "In-Network YouTube Performance Estimation in Light of End User Playback-Related Interactions." In *2019 QoMEX*, pp. 1-3. IEEE, 2019.
[4] Bartolec, Ivan, et al. "Inclusion of End User Playback-Related Interactions in YouTube Video Data Collection and ML-Based Performance Model Training." In *2020 QoMEX*, pp. 1-6. IEEE, 2020.

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