Quality of Experience Driven Video Encoding Adaptation Strategies for Cloud Gaming under Network Constraints

Student: Ivan Slivar
Faculty of Electrical Engineering and Computing
Department of Telecommunications
Zagreb, Croatia
ivan.slivar@fer.hr

Advisor: Lea Skorin-Kapov
Faculty of Electrical Engineering and Computing
Department of Telecommunications
Zagreb, Croatia
lea.skorin-kapov@fer.hr

***Abstract*—Cloud gaming is a highly interactive service that allows on-demand streaming of game content onto non-specialized devices (e.g., PC, tablet, smart TV, etc.). With available network resources varying over time, there is a need for efficient and dynamic service adaptation strategies on the game server to meet different bandwidth availabilities. The main objective of this research is to specify video encoding adaptation strategies to optimize end user QoE for cloud gaming under variable system and network conditions. The research hypothesis is that the novel and context-aware video encoding adaptation strategies can be exploited to improve end user QoE in comparison with state-of-the-art approaches for cloud gaming service adaptation in light of constrained system or network resources.**

I. Motivation

The cloud gaming paradigm has been recognized as a promising shift towards enabling the delivery of high-quality games to nearly any end user device, thus alleviating the need for devices with high-end graphics and processor support. With powerful servers being responsible for executing the game logic, rendering of the 2D/3D virtual scene, video encoding, and streaming game scenes to client devices, the result is a significant increase in downlink bandwidth requirements to secure a good level of Quality of Experience (QoE) as compared to traditional online gaming. A challenge faced by cloud gaming providers is configuration of the video encoding parameters used for game streaming with respect to different available network bandwidth conditions. The cloud gaming server has very limited control over network latency, apart from reducing its own sending rates to avoid filling up router queues during congestion. Hence, codec reconfiguration decisions made by the cloud gaming server (in terms of chosen target bitrate and frame rate values) are driven by measured available effective bandwidth. Additionally, current developed QoE models [1], [2], [3] can for the most part be applied to only one specific game for which they were primarily derived for due to significant differences (in terms of graphics detail, gameplay pace, input rate, etc.) between games that are assigned to the same game category based on present game genre classification. Therefore, there is a need to design an appropriate game categorization for cloud gaming based on objective game characteristic that can be later used as a tool when aiming to develop accurate QoE models for derived game categories. Consequently, such a categorization could then be used for determining optimal adaptation strategies for categories of games, which could in the future automate the process of deciding on the best encoding adaptation strategy for a particular game.

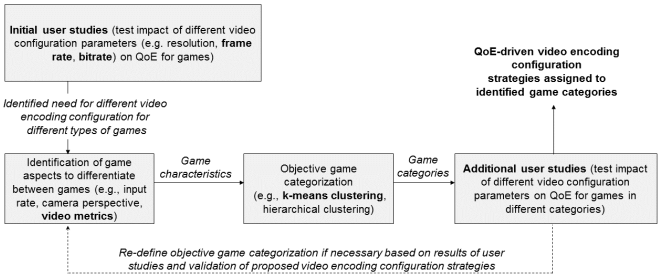

Fig. 1: Research methodology

II. Methodology and current results

Overall methodology of the research presented in the paper is shown in Figure 1. The results of two initial user studies involving 80 participants and three tested games reported in [4] indicate that different video encoding adaptation strategies should likely be applied for different types of games when aiming to maximize QoE. In the mentioned paper, we investigated the impact of video encoding parameters on QoE, i.e. we manipulated video frame rate and bitrate, consequently controlling image quality and smoothness of gameplay. Based on the subjective results (shown in Figure 2) and statistical analysis reported in the paper, main findings were that different codec configuration strategies may be applied to different types of games in light of bandwidth availability constraints so as to maximizes player QoE (this was clearly shown using two games belonging to different genres (Serious Sam 3 and Hearthstone)), and in certain cases, the same codec configuration strategy may be applied to games belonging to different genres (Serious Sam 3 and Orcs must Die). Hence,

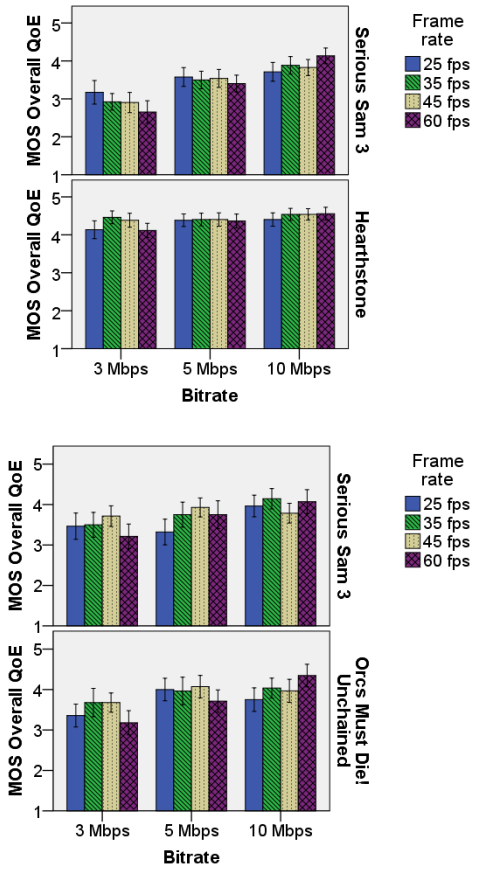

Fig. 2: Subjective ratings of overall QoE (95% CI) for tested games (taken from [4])

we concluded that the game type tested clearly needs to be taken into account when evaluating the QoE of cloud games.

As a result, a detailed analysis of digital game characteristics was conducted to identify game aspects which can be used to identify the differences between video streams of different games in cloud gaming. We gathered a large number of video game play traces and collected player actions from 25 different games. For each of the tested games, we recorded between 5-10 gameplay video traces that lasted exactly 30 seconds each in order to obtain a large enough sample of gameplay for each game. Alongside gameplay recording, we also measured the intensity of user interaction, thus collecting mouse and keyboard input during gameplay. Based on a k-means analysis of obtained data (also reported in [4]), we found that games may be grouped into 2 clusters characterized by objective video metrics. To visualize the obtained clusters, a scatter plot of analysed objective video metrics (Figure 3) is given. It can be observed that Cluster 2 contains games with high video motion that contains a smaller amount of video information. On the other hand, Cluster 1 contains games with low video motion, however when the objects in the screen move, the coding block size is quite large. The results could serve as a basis for proposition of a novel game categorization that could be utilized for selecting appropriate video configuration

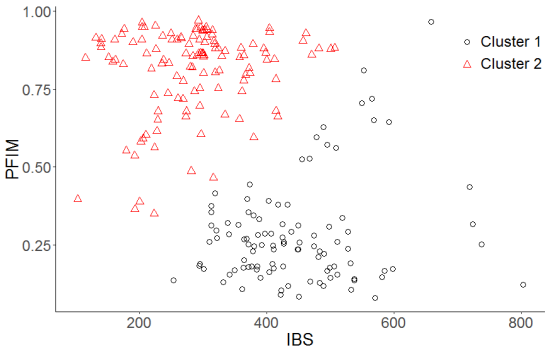

Fig. 3: Video metrics scores for the clusters (taken from [4])

strategies for different types of games.

III. Conclusion

While cloud gaming represents a promising paradigm shift in the domain of online gaming, challenges arise in meeting the strict bandwidth and delay requirements of game streaming. Such challenges inherently call for codec configuration and adaptation strategies capable of meeting strict player QoE requirements and adapting the service to variable network conditions. Given the wide diversity of games and their corresponding QoE requirements, it is clear that different strategies may be applied to different categories of games. Two subjective laboratory studies have been conducted which provide valuable insights into the impacts of different codec configuration strategies on three different games. Consequently, using as a basis the subjective results, we proposef a novel game categorization based on objective video metrics that could be utilized for deriving appropriate video encoding configuration strategies for cloud gaming. The proposed game categorization could be used for determining adaptation strategies for clusters of games, which could in the future automate the process of deciding on the best video encoding strategy for a particular game, alleviating the need to conduct subjective studies for additionally considered (or newly emerging) games.

Acknowledgment

This work has been supported by the Croatian Science Foundation under the project UIP-2014-09-5605 (Q-MANIC)

References

[1] H.-J. Hong, C.-F. Hsu, T.-H. Tsai, C.-Y. Huang, K.-T. Chen, and C.-H. Hsu, "Enabling Adaptive Cloud Gaming in an Open-Source Cloud Gaming Platform," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. PP, no. 99, pp. 1–14, 2015.

[2] I. Slivar, L. Skorin-Kapov, and M. Suznjevic, "Cloud gaming QoE models for deriving video encoding adaptation strategies," in *Proceedings of the 7th International Conference on Multimedia Systems*. ACM, 2016, p. 18.

[3] I. Slivar, M. Suznjevic, and L. Skorin-Kapov, "The impact of video encoding parameters and game type on QoE for cloud gaming: A case study using the Steam platform," in *Quality of Multimedia Experience (QoMEX), 2015 7th Intl. Workshop on*, May 2015, pp. 1–6.

[4] I. Slivar, L. Skorin-Kapov, and M. Suznjevic, "Game Categorization for Deriving QoE-Driven Video Encoding Conguration Strategies for Cloud Gaming," *submitted for review in ACM Transactions on Multimedia Computing, Communications*, 2017.