Network-based Online Video freeze prediction in HTTP Adaptive Streaming

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***Abstract*—HTTP adaptive streaming (HAS) has become a prevailing technology for media delivery technology over mobile and fixed networks. The client's Quality of Experience (QoE) for HAS video sessions is particularly of interests in network providers and Content Delivery Network (CDN) providers. But typically, network providers are not able to assess to clients to obtain QoE relevant parameters, such as freeze, initial loading time, quality switches, etc.**

In our previous work, we designed a HAS QoE monitoring system based on the sequence of HTTP GET requests collected at the CDN nodes. The system relies on a technique called session reconstruction to retrieve the major QoE parameters without modification of the clients. However, session reconstruction is computationally intensive and requires manual configuration of reconstruction rules. To overcome the limitations of session reconstruction, this paper proposes a scalable machine learning (ML) based scheme that detects video freezes using a few high-level features extracted from the network-based monitoring data. We determine the discriminative features for session representation and assess five potential classifiers. We select the C4.5 decision tree as classifier because of its simplicity, scalability, accuracy, and explainability. To evaluate our solution, we use traces of Apple HTTP Live Streaming video sessions obtained from a number of operational CDN nodes and traces of Microsoft Smooth Streaming video sessions acquired in a controlled lab environment. Experimental results show that an accuracy of about 98%, 98%, and 90% can be obtained for the detection of a video freeze, a long video freeze, and multiple video freezes, respectively. Excluding log parsing, the computational cost of the proposed video-freeze detection is 33 times smaller than needed for session reconstruction.

***Index Terms*—HTTP Adaptive Streaming, Decision Tree C4.5, Freeze Prediction, Quality of Experience**

I. Introduction

VIDEO streaming has occupied more than half of traffic over the Internet. In recent years, video delivery over traditional best-effort Internet becomes very popular. Among this, HTTP Adaptives Steaming (HAS) is increasingly adopted and has become a key technology. HTTP adaptive streaming systems [1] include MPEG-DASH, Apple's HTTP Live Streaming, Microsofts Smooth Streaming, Adobes Dynamic Streaming, etc. Typically, in a HAS architecture, video content, hosted on an HTTP Web server, is encoded in different quality levels (bit-rates), and chunked into independent segments. A HAS client requests the segments with different qualities in a linear way using HTTP GET requests and downloads them using plain HTTP progressive download. The retrieved segments can be played back as a seamless video, possibly switching among different quality levels. The key feature of HAS is that it is the client that is responsible for determining which quality level to download according to its available resources. Server/network providers do not have the control over the quality requests. One of the main advantages of introducing HAS as a delivery/playout method is that, the client could adapt its quality requests based on the perceived bandwidth: it enables the client to smoothly play the video with a low quality level even when the perceived bandwidth is very limited, while when a high bandwidth is available, it supports the client to demand high quality levels.

With the growing pervasion of HAS deployments, network and CDN providers raise interests in knowing the end-user quality of experience (QoE) of HAS sessions over their network, because QoE reveals the satisfaction of their users. Although QoE is the subjective perception of end-users, the objective QoE relevant parameters, including the statistics of bit-rates, freezes frequency and freeze durations, etc, can be used to model the end-users' Mean Opinion Score (MOS) [2]. This inspires network/CDN providers to obtain the QoE relevant parameters, as an indirect way to evaluate the satisfaction of end-users. While a HAS client may report these parameters to the Web server (for instance, enabling Advanced Logging in Microsoft Internet Information Services (IIS) could require Microsoft Silverlight clients to send the status of medie content consumption to the IIS server at a regular time basis), typically it does not report these parameters to intermediate network nodes; they are only able to intercept the sequence of HTTP GET requests sent from the client to the server/CDN. So retrieving QoE relevant parameters from the sequence of HTTP GET requests within a single video session is a plausible method to evaluate end-user's QoE. Indeed, in our previous study [3], we demonstrated that from the sequence of HTTP GET requests collected at intermediate network elements, the HAS session can be reconstructed to derive all QoE related parameters. These parameters include the average playout quality, changes in the play-out quality, rebuffering due to buffer starvation, rebuffering caused by interactivity, etc. The session reconstruction technique relies on some manually rules discovered by the trial-and-error method, without modifying the original HAS client, and thus is a feasible network based method to evaluate the video delivery quality of HAS.

Among all objective QoE relevant parameters, freeze/re-

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buffering is undoubtedly the most deleterious factor to destroy end-users' satisfaction and engagement. The 2015 annual report of Conviva [4] shows that 28.8% of video sessions experience a rebuffering event, but only 1% increase of rebuffering could reduce the video engagement with 14 minutes. Although the session reconstruction has shown its effectiveness, the effort of the manual trial-and-error rule discovery reduces its generalization capability; one has to manually re-configure the construction rules for a new HAS deployment.

Freeze is the most important factor. but it has to rely on session reconstruction. use machine learning.

contributions. (1) freeze detection (2) online freeze prediction

paper organization

II. Related work

HAS QoE; network/server side QoE evaluation study of Freeze

III. proposed frame work

A. Architectural description

B. decision tree C4.5

IV. performance evaluation

A. experimental setup

1) session-based freeze detection:

2) request-based online freeze prediction:

B. Dataset

C. Field data set

D. lab data set

E. openflow data set

F. discussion

V. Conclusions

Subsection text here.

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Jane Doe Biography text here.