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“New Approaches to Improving Live Video Delivery over Content Delivery Networks”

Department of Computer Science

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Abstract

The live streaming services have gained extreme popularity in recent years. The spiky traffic, as well as the real-time property of live videos, make it challenging for content delivery networks (CDNs) to guarantee the Quality-of-Experiences (QoE) of viewers. The caching and delivery mechanism of live videos over the current CDN architecture has its limitation since the current CDNs are not designed for live videos in the first place. As a result, it may lead to deteriorated QoE to the end viewers such as long startup latency. In this dissertation, with the help of CDN edge servers, we focus on the QoE improvement solutions of three problems in live video delivery, covering the research fields of i) multi-CDN content delivery, ii) QoE optimization of HTTP-based live video delivery, and iii) live video replication over edge CDN servers.

First, in order to improve the content delivery performance under current multi-CDN strategies, we propose a feasible and efficient solution to multi-CDN, termed as CDN semi-federation. Compared with a full multi-CDN federation, CDN semifederation can better schedule and utilize the resources from multiple CDNs without requiring full CDN interconnection (CDNI), which poses significant technical obstacles not easy to solve in the short term. The semi-federation model requires an authoritative and trusted third-party consortium formed by voluntary CDN vendors, who need to disclose their dynamic information (e.g., PoP footprints and service capabilities) to the consortium. The authoritative consortium adopts a centralized control to provide traffic delivery guidance to CDNs by leveraging the resources from multiple CDNs and reshaping the traffic demand assigned to each CDN. Compared with CDNI, CDN semi-federation: i) releases the CDN vendors from the complex technical and business obstacles of interconnecting with multiple CDNs, and ii) avoids the sub-optimal content delivery decisions made by distributed CDNs.

Second, to optimize the QoE of HTTP-based live video delivery over CDN edge servers, we propose a reinforcement learning-based dynamic IVS selection scheme (Rldish) deployed on edge CDN server to dynamically select a suitable initial video segment (IVS) of a live streaming. Rldish uses a real-time exploration and exploitation
(E2) model to learn the IVS selection automatically, and is deployed as a virtual network function (VNF) on the CDN edge server by the CDN operator. Rldish makes the IVS decisions on a per-stream basis to avoid high overhead in per-user based throughput estimation. Since an edge CDN server generally serves its proximal end users, viewers accessing the same live video usually share the common video delivery path from the origin server to the edge and generally experience the similar network conditions when fetching the same video from the edge. Based on this observation, Rldish continuously updates the currently optimal decisions on IVS selection for the live viewers on a per-stream basis, based on the real-time QoE measurements and feedback. The decisions are then updated into the media playlist files of each stream for the subsequent live viewers.

Third, to solve the cache miss problem in edge-assisted live video delivery, we propose a proactive live video edge replication scheme (PLVER). PLVER first conducts a one-to-multiple stable allocation between edge clusters and user groups to balance the load of live requests over edge servers. In this way, each user group is assigned to its most preferred edge cluster whenever possible. Based on the allocation result, PLVER then proposes an efficient proactive live video edge replication (push) algorithm to speed up the edge replication process by using real-time statistical viewership of the user groups allocated to a cluster. We conduct extensive trace-driven evaluations, covering 0.3 million Twitch viewers and more than 300 Twitch channels. The results demonstrate that with PLVER, edge servers can carry 28% and 82% more traffic than the auction-based replication method and the caching on requested time method, respectively.