Optimizing User Quality of Experience through Overlay Routing, Bandwidth Management and Dynamic Trans-Coding

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ABSTRACT

Accessing multimedia services via fixed and wireless networks has become common practice. These services are typically much more sensitive to packet loss, delay and/or congestion than traditional services. In particular, multimedia data is often time critical and, as a result, network issues are not well tolerated and significantly deteriorate the user’s Quality of Experience (QoE). Therefore, the authors propose a QoE optimization platform that is able to mitigate problems that might occur at any location in the delivery path from service provider to customer. More specifically, the distributed architecture supports overlay routing to circumvent erratic parts of the network core. In addition, it comprises proxy components that realize last mile optimization through automatic bandwidth management and the application of processing on multimedia flows. This paper introduces a trans-coding service for this proxy component which enables the transformation of H.264/AVC video flows to an arbitrary bitrate. Through representative experimental results, the authors illustrate how this addition enhances the QoE optimization capabilities of the proposed platform by allowing the proxy component to compute more flexible and effective bandwidth distributions.

Keywords: Dynamic Rate Shaping, H.264/AVC Video Trans-coding, Network Traffic Shaping, NIProxy,

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Overlay Routing, QoE Optimization
INTRODUCTION

In recent years, a popularization of the networked access of multimedia services has occurred. Compared to traditional services like web browsing and e-mail, these services impose much stricter requirements on the transportation network. For instance, interactive applications such as VoIP and online gaming demand a low delay to guarantee a fluid operation. As another example, packet loss negatively impacts video streaming services since it will rapidly degrade playback at receiver-side due to the introduction of perceptual distortions. Complicating matters even further is the fact that, due to the recent trend towards mobile computing, service providers are increasingly targeting not only fixed but also mobile customers. Since fixed and mobile devices as well as networks have largely divergent capabilities, a highly heterogeneous usage environment is created, which in turn results in growing service dependability as well as adaptation requirements.

Empirical experience has proven that current generation networks are not always capable of guaranteeing that the requirements imposed by multimedia services are satisfied. For instance, the Internet only provides best-effort routing, meaning no guarantees are given regarding the level of service that will be experienced by network packets. The access part of a client’s network connection is another possible source of complications, mainly due to its bandwidth capacity constraints. Insufficient last mile bandwidth may be available to support all the user’s active services (or even to receive all content that is being exchanged as part of a single multimedia service). This will likely give rise to congestion and hence also an increase in packet loss and delay in case adequate techniques for the adaptation of network traffic are lacking.

Based on these observations, we argue that current networks frequently fail to provide customers of multimedia services with an acceptable usage experience or, more formally, Quality of Experience (QoE). In our previous work we therefore introduced a two-tier overlay platform which supports full end-to-end user QoE optimization (De Vleeschauwer et al., 2008). On the one hand, the proposed architecture enhances data dissemination in the network core by providing an overlay routing service which improves resilience to issues like failing or congested network links. On the other hand, proxy servers deployed close to end-users provide functionality to deliberately apportion bandwidth among network flows on the last mile and simultaneously act as service provision platform since they are also capable of applying processing on (multimedia) network flows.

In this paper, we present a novel transcoding service for the proxy components of our proposed overlay architecture which enables them to dynamically adapt the bitrate of H.264/AVC-encoded video bit-streams. Given the complexity of the H.264/AVC specification, cascading a full decode and subsequent re-encode step would limit the applicability of the trans-coder to off-line scenarios. The transcoding service therefore operates entirely in the compressed domain to enable real-time video transformation. As a secondary contribution, we illustrate how the capabilities of the proxy component’s network traffic shaping functionality and the novel H.264/AVC trans-coding module can be bundled to produce highly dynamic and flexible bandwidth management results. As will be validated using representative experimental results, the availability of the H.264/AVC service considerably extends the QoE optimization performance of our platform.

The outline of the remainder of this paper is as follows. The next Section provides an overview of the architecture of the proposed overlay platform and harbors a detailed description of each of the platform’s constituting components. In the following Section a thorough evaluation of our platform and, in particular, of its novel H.264/AVC video trans-coding capabilities is presented. Through representative experimental results, this Section will demonstrate the platform’s ability to beneficially impact user QoE. Next, an overview of related work is given. The final Section draws our conclusions.
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