Over-the-Top Content Delivery: State of the Art and Challenges Ahead

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ABSTRACT

In this tutorial we present state of the art and challenges ahead in over-the-top content delivery. It particular, the goal of this tutorial is to provide an overview of adaptive media delivery, specifically in the context of HTTP adaptive streaming (HAS) including the recently ratified MPEG-DASH standard. The main focus of the tutorial will be on the common problems in HAS deployments such as client design, QoE optimization, multi-screen and hybrid delivery scenarios, and synchronization issues. For each problem, we will examine proposed solutions along with their pros and cons. In the last part of the tutorial, we will look into the open issues and review the work-in-progress and future research directions.

Categories and Subject Descriptors

H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *Video.*

General Terms: Algorithms, Design, Experimentation, Measurement, Performance, Standardization.

Keywords: Adaptive Media Streaming, Dynamic Adaptive Streaming over HTTP, MPEG-DASH, Over-the-top Video.

1. INTRODUCTION

Recently, traditional TV services, Internet TV and mobile streaming services have started converging, which means a particular piece of content can be reached over different types of network. Additionally, new multimedia services such as hybrid-broadcast-broadband and multi-screen are emerging. It is expected that this convergence trend will continue until consumers can get a seamless experience across different platforms for a variety of multimedia services. The massive heterogeneity in terms of consumer devices, network capabilities, and user expectations requires efficient solutions for the transport of modern media in an interoperable and universal fashion. In particular, in recent years, the Internet has become an important channel for the delivery of multimedia. The Hypertext Transfer Protocol (HTTP) is widely adopted on the Internet and it has also become a primary protocol for the delivery of multimedia content.

Standards developing organizations (SDOs) such as MPEG have developed various technologies for multimedia transport and encapsulation, e.g., MPEG-2 Transport Stream and ISO Base Media File Format. These technologies have been widely adopted and deployed for different applications and services, such as digital broadcasting, audio and video transport over the Internet and streaming to mobile phones. At the same time, many other SDOs such as the IETF, IEEE, and 3GPP have provided various protocols to deliver multimedia content packetized or packaged by such MPEG transport technologies.

In practice, however, these multimedia services are typically deployed over best-effort networks using existing infrastructure without any timely delivery guarantees. Thus, the quality as perceived by a consumer – referred to as Quality of Experience (QoE) – becomes critical for the success of these services and their providers. Insufficient network resources may lead to an increased initial delay before service startup or interruptions during the media playout. The resulting waiting and stalling times have a major impact on the QoE. For online video streaming, both live and on-demand, there are several possibilities to adapt the video quality based on the actual network conditions to avoid outages by adaptively managing the playout buffer and/or adaptively changing the bitrate, resolution, and/or frame rate.

The goal of this tutorial is to provide an overview of adaptive media delivery, specifically in the context of HTTP adaptive streaming (HAS) including the recently ratified MPEG standard "Dynamic Adaptive Streaming over HTTP (DASH)" [1][2]. One of the essential differences between HAS and earlier streaming solutions is that the client is in charge of adaptation, thus, directly influences the QoE. This client behavior is not standardized and differentiates players in the market today. In large-scale deployments, client design becomes extremely important for success.

In this tutorial, we will present essential components for an end-to-end HAS system including means for the content creation, distribution, and consumption. The main focus of the tutorial will be on the common problems in HAS deployments such as client design, QoE optimization, multi-screen and hybrid delivery scenarios, and synchronization issues. For each problem, we will examine proposed solutions along with their pros and cons. In the last part of the tutorial, we will look into the open issues and review the work-in-progress and future research directions.

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2. TUTORIAL OUTLINE AND OVERVIEW

The tutorial outline is as follows:

- Introduction to adaptive media delivery and specifically HTTP adaptive streaming (HAS).
- End-to-end HAS workflows: From content creation to consumption.
- Common problems in HAS: QoE optimization, multi-screen and hybrid delivery, synchronization issues.
- Open issues and future research directions in HAS.

Adaptive media streaming is generally referred to as media delivery where the overall system adapts itself to varying conditions both prior to and during the streaming session. In the past decade we observed a transition from push-based streaming (utilizing the RTSP/RTP protocol family) to pull-based streaming (adopting HTTP infrastructure). While the former allows for tailor-made solutions, it requires dedicated infrastructure support whereas the latter is built on top of the existing Internet without explicit support from the underlying networking infrastructure. The advantage of HTTP adaptive streaming is based on its client-centric design, efficient media codecs, and best-effort support from the networking infrastructure. Standards like MPEG-DASH enable interoperability among different implementations.

The end-to-end HAS workflow comprises the generation, provisioning, delivery, and consumption of multiple, time-aligned, segmented versions of the same content which are referred to as representations. Segments of each representation are uniquely identifiable using HTTP uniform resource locators (URLs). The actual provisioning of the content involves standard HTTP servers and its delivery includes also standard HTTP infrastructure such as caches, proxies, and content distribution networks (CDNs). Finally, the consumption requires a client implementation which issues timely HTTP requests for segments of a given representation based on its context environment such as device, codec, bandwidth, resolution, language, subtitles, views, etc.

The client module, which is responsible for issuing the HTTP requests, is commonly referred to as adaptation logic and typically not defined within standards like MPEG-DASH and, thus, is subject to academic research and industry competition. The adaptation logic is also responsible for delivering a seamless user experience including QoE optimizations. New use cases like multi-screen and hybrid (broadband-broadcast) introduce new challenges to HAS clients. For example, social TV requires inter-destination media synchronization where the media playout of geographically distributed users needs to be synchronized in the presence of a real-time communication channel [3].

Finally, open issues and future research directions in HAS include but are not limited to: multi-path/-source delivery, transport (TCP) and application (HTTP) layer optimizations, QoE modeling and quality-based streaming.

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Christian Timmerer is an Associate Professor at the Institute of Information Technology (ITEC), Multimedia Communication Group (MMC), Alpen-Adria-Universität Klagenfurt, Austria. His research interests include immersive multimedia communication, streaming, adaptation, and Quality of Experience (QoE). He was the general chair of QoMEX'13, WIAMIS'08, AVSTP2P'10 (co-located with ACMMM'10), WoMAN'11 (co-located with ICME'11), and TPC co-chair of QoMEX'12. He has participated in several EC-funded projects, notably DANAE, ENTHRONE, P2P-Next, ALICANTE, SocialSensor, and ICoSOLE. He is an Associate Editor for IEEE Computer Science Computing Now, Area Editor for Elsevier Signal Processing: Image Communication, Review Board Member of IEEE MMTC, editor of ACM SIGMM Records, and member of ACM SIGMM Open Source Software Committee. He also participated in ISO/MPEG work for several years, notably in the area of MPEG-21, MPEG-M, MPEG-V, and DASH (incl. DASH Industry Forum). He received his PhD in 2006 from the Klagenfurt University. Follow him on http://www.twitter.com/timse7 and subscribe to his blog http://blog.timmerer.com.

Ali C. Begen is with the Video and Content Platforms Research and Advanced Development Group at Cisco. His interests include networked entertainment, Internet multimedia, transport protocols and content delivery. Ali is currently working on architectures and protocols for next-generation video transport and distribution over IP networks. He is an active contributor in the IETF and MPEG, and has given a number of keynotes, tutorials and guest lectures in these areas.

Ali holds a Ph.D. degree in electrical and computer engineering from Georgia Tech. He received the Best Student-paper Award at IEEE ICIP 2003, the Most-cited Paper Award from Elsevier Signal Processing: Image Communication in 2008, and the Best-paper Award at Packet Video Workshop 2012. Ali has been an editor for the Consumer Communications and Networking series in the IEEE Communications Magazine since 2011 and an associate editor for the IEEE Transactions on Multimedia since 2013. He served as a general co-chair for ACM Multimedia Systems 2011 and Packet Video Workshop 2013. He is a senior member of the IEEE and a senior member of the ACM. Further information on Ali's projects, publications, presentations and professional activities can be found at http://ali.begen.net.

5. REFERENCES

[1] ISO/IEC 23009-1:2014. Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats.

[2] Sodagar, I. 2011. The MPEG-DASH Standard for Multimedia Streaming Over the Internet. *IEEE MultiMedia* 18, 4 (October 2011), 62-67.

[3] Timmerer, C., Rainer, B. 2014. The Social Media Experience. IEEE Computer 47, 3 (March 2014), 67-69.