Over-the-Top Content Delivery

STATE OF THE ART AND CHALLENGES AHEAD

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Cover Sheet

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

300 word abstract (for inclusion in registration materials): Over-the-top content delivery is becoming increasingly attractive for both live and on-demand content thanks to the popularity of platforms like YouTube, Vimeo, Netflix, Hulu, Maxdome, etc. In this tutorial, we present state of the art and challenges ahead in over-the-top content delivery. In 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.

The intended audience: This tutorial includes both introductory and advanced level information. The audience is expected of understanding of basic video coding and IP networking principles. Researchers, developers, content and service providers are all welcome.

Learning Objectives: Upon attending this tutorial, the participants will have an understanding of the following:

- Principles of adaptive media delivery, specifically HTTP adaptive streaming
- Content generation, distribution and consumption workflows
- Quality of Experience in adaptive streaming
- Current and future research as well as standards and emerging technologies in this area

Area of the tutorial: Multimedia networking and communication

Keywords: Adaptive Media Streaming, Dynamic Adaptive Streaming over HTTP, MPEG-DASH, Over-The-Top Video Streaming

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Please note that this proposal can be considered as both “Single presentation (25 minutes)” and “Full session (90 minutes)”. Recent versions of this tutorial can be found here http://www.slideshare.net/christian.timmerer.
Recent advances in multimedia delivery, especially in the context of HTTP adaptive streaming (HAS), have led to an increased demand for adaptive content delivery. HAS allows for the adaptation of media content to the current network conditions and client device capabilities, ensuring a high-quality experience for the end user. However, the adaptation process requires careful management to ensure optimal performance and user satisfaction.

In this tutorial, we will provide an overview of adaptive media delivery, focusing specifically on HTTP adaptive streaming. We will describe the key technologies and protocols involved, including HTTP, Dynamic Adaptive Streaming over HTTP (DASH), and other multimedia transport standards. We will also discuss the challenges and future directions in this rapidly evolving field.

**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 user equipment and 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 used 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., MPEG2-TS (Transport Stream) and MPEG4 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, etc. 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 infrastructures 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 to 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-DASH standard. 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

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*(Extended Abstract)*

Bioography of Presenter

**Christian Timmerer** received his M.Sc. (Dipl.-Ing.) in January 2003 and his Ph.D. (Dr.techn.) in June 2006 (for research on the adaptation of scalable multimedia content in streaming and constraint environments) both from the Alpen-Adria-Universität Klagenfurt. He is currently an Associate Professor at the Institute of Information Technology (ITEC) within the Multimedia Communication Group. His research interests include immersive multimedia communication, streaming, adaptation, Quality of Experience, and Sensory Experience.

He has published more than 150 papers in these areas and he has organized a number of special sessions and issues in this domain, e.g., “Special Session on MMT/DASH” (MMsys 2011, followed by a special issue in Signal Processing: Image Communication, 2012), “Special Issue on Adaptive Media Streaming” (IEEE JSAC, published 2014). Furthermore, he was the general chair of WIAMIS 2008, QoMEX 2013, and QCMen 2014; will be general chair of ACM Multimedia Systems 2016. He is an editorial board member of IEEE Computer, associate editor for IEEE Transactions on Multimedia, area editor for the Elsevier journal on Signal Processing: Image Communication and a key member of the Interest Groups (IG) on Image and Video Coding as well as Quality of Experience and Director of the Review Board of the IEEE Multimedia Communication Technical Committee. Finally, he writes a regular column for ACM SIGMM Records where he serves as an editor and he is a member of the ACM SIGMM Open Source Software Committee.

Dr. Timmerer participated in the work of ISO/MPEG for more than 10 years, notably as the head of the Austrian delegation, coordinator of several core experiments, co-chair of several ad-hoc groups, and as an editor for various standards, notably the MPEG-21 Multimedia Framework and the MPEG Extensible Middleware (MXM which became MPEG-M). His current contributions are in the area of MPEG-V (Media Context and Control) and Dynamic Adaptive Streaming over HTTP (DASH), for which he also serves as an editor. He received various ISO/IEC certificates of appreciation.

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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.

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.

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.