Fraunhofer FOKUS

ZATTOO

Whitepaper

Building Unicast IPTV services leveraging OTT streaming technology and adaptive streaming

Fraunhofer FOKUS & Zattoo

May 19th 2014

Motivation

Internet delivered Video is at the tipping point and became a mass-market driver for over the top (OTT) video solutions. The massive growth of consumed Internet video (Figure 1) was enabled by widely available broadband access in households providing sufficient and affordable bandwidth. Internet services became commodity. In Germany by end of 2012 55% of sold TV devices are hybrid[1], meaning they combine traditional DVB access with OTT services from the open Internet. Devices for video consumption became more powerful, ubiquitous and easy to use –there are more than 13 million SmartTVs available in German households, which is already more than 30% of the overall TV penetration[2]. Furthermore, open Web standards and tools evolved massively. HTML5, JavaScript and CSS is omnipresent and one of the key driver for the success of video enabled web applications and services. YouTube alone accounts for more than one billion unique users visiting the site per month, resulting in more than six billion hours of video watched[3]. While new content is provided in high quality, client-sided limitations do not always allow for consumption of the best available quality at any given time. Variations in available bandwidth can easily lead to buffer underruns and video freezes while new content has to be fetched to resume playback. Alternatively, a lower quality setting could be used to prevent such freezes, which might well lead to not using the best possible quality most of the time.

One approach to vanquish these issues is the introduction of adaptive bitrate streaming. Adaptive streaming focuses on selecting the most appropriate quality media in real-time, based upon evaluation of criteria that might impede and limit the given possibilities, such as available bandwidth and CPU capacity on the client side. Therefore, video content needs to be provided in multiple bitrates and resolutions allowing media clients to request and playback the most appropriate quality adaptively. Most relevant adaptive streaming solutions are the proprietary solutions Apple HTTP Live Streaming (HLS), Adobe HTTP Dynamic Streaming (HDS), Microsoft Smooth Streaming and the standardized MPEG Dynamic Streaming over HTTP (MPEG DASH).

A second approach, mainly for First Screen IP-based TV services (IPTV) in operator managed networks, is to leverage direct network peering between a service provider or service operator and the network operator. With the network operator managing the distributed content he receives through the direct network peering,

[1] AGF - TV viewing data 2012
www.agf.de/showfile.phtml/service/zumdownload/130925%20Sehdauer%202012%20nach%20Zielgruppen.pdf?foid=60752
[2] Digital TV viewing evolution
http://www.agf.de/showfile.phtml/service/zumdownload/130922%20Entwicklung%20der%20digitalen%20TV-Nutzung.pdf?foid=60755
[3] http://www.youtube.com/yt/press/statistics.html

he makes sure that the IPTV service is prioritized and can be streamed at the maximum bitrates and quality available.

This Unicast IPTV approach has massive consequences: Traditional IPTV services are built on multicast-enabled managed networks operated by large telecommunication or network providers. As experience has shown, such deployments were bound to heavy investments in the network infrastructure, end devices as well as operations to enable a managed IP-based multicast transmission of TV content to households. **New IP-based video services need to be highly flexible, cost effective and prepared to be available an all major platforms and end devices without the need for specific hardware or network prerequisites. These new Unicast IPTV services build on HTTP-based, adaptive video delivery via direct network peering or the open Internet using unicast delivery.**

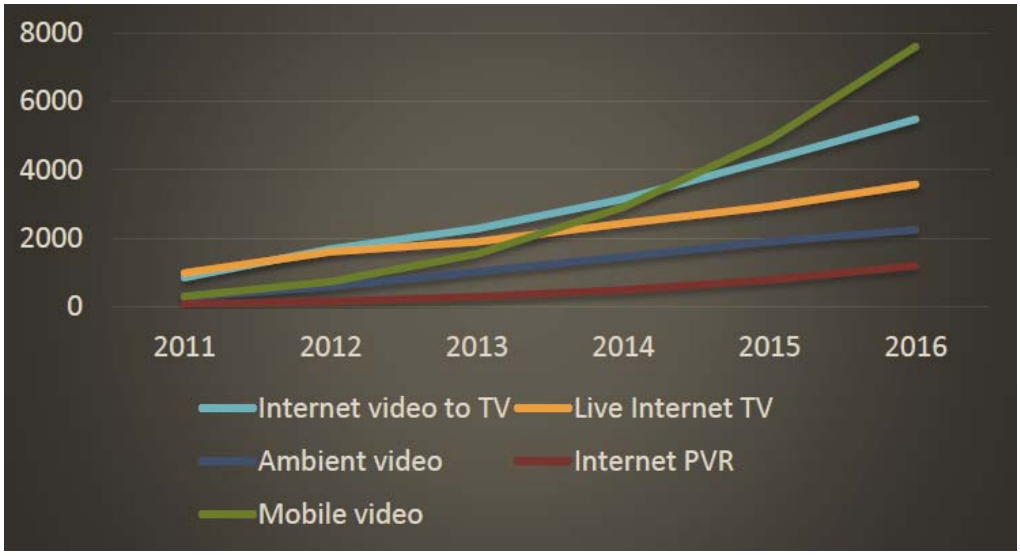

Figure 1 – Consumer Internet Video 2011-2016 in PB/month (visual networking index 2013 by CISCO[4])

[4] The Cisco® Visual Networking Index (VNI) Global Mobile Data Traffic Forecast http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

Setting the scene – a technical overview

Video streaming generally consists of an audio and video source fed into an encoder, transmitted to a media server, which then supplies connected clients with streaming data. In principle, there are two different models to transport the audio and video packets: unicast and multicast delivery:

Unicast offers a one-to-one relationship between the server and the client receiving the stream – **Multicast** on the other hand offers a one-to-many relationship (see Figure 2). It serves a single stream replicated throughout the network so that any client may tune in. Thus, it seems that multicast should be great for live video delivery while unicast might be the better choice for video on demand. That is theory – in practice there is no black and white. **As multicast is based on UDP, it is a non-connection oriented protocol providing a best effort delivery of media packets without native support of packet and flow control**. Furthermore, multicast lack of TCP windowing and slow-start mechanisms may result in network congestion. **Enhanced efficiency** through the control of network traffic, reduction of server load or e.g. elimination of traffic redundancy by multicast delivery is feasible but **will in practice require additional multicast enabled hardware, complex network management and does usually come with high costs**.

By nature, **the open Internet is not multicast ready since it is built for unicast delivery using connection oriented protocols as TCP**. With the advent of HTTP based streaming protocols, **video delivery can be built into every network without any need for specialized hard or software**, complex backbone infrastructures and cost intensive network management. This even allows for IPTV services (Live TV, Catch-up, VOD) targeting the First Screen. Prioritization of video traffic over other, non-time-critical traffic can easily be achieved by standard network management mechanisms through e.g. load balancing and routing rules. One of the main benefits of unicast delivery is the fact, that there is **absolutely no need for special hardware and protocol support at the client side** as e.g. multicast capable routers or set-top-boxes.

Adaptive streaming even allows compensating for changing network conditions while still providing users with the decent quality. No bandwidth needs to be dedicated to specific video streams as streams consists of small, ordered media segments instead of a continuous stream. Adaptive streaming enabled clients splice these segments together to a video stream as defined in the appropriate manifest for each content. Unicast is supported by any IP-enabled client-device and the support of adaptive streaming through e.g. HLS, HDS, Smooth Streaming or MPEG DASH is available on all major client platforms. This means that **all kinds of clients can be served with live or on demand streams using the exact same technology**. To recap, this is fundamental different to multicast delivery and multicast enabled clients as special set-top-boxes. From a service perspective, there is an additional benefit for unicast: as **unicast** by nature is built for individual consumption, it **perfectly builds the basis to provide personalized streaming services** as on demand assets, catch-up TV, and time shifted content as well as network recording capabilities.

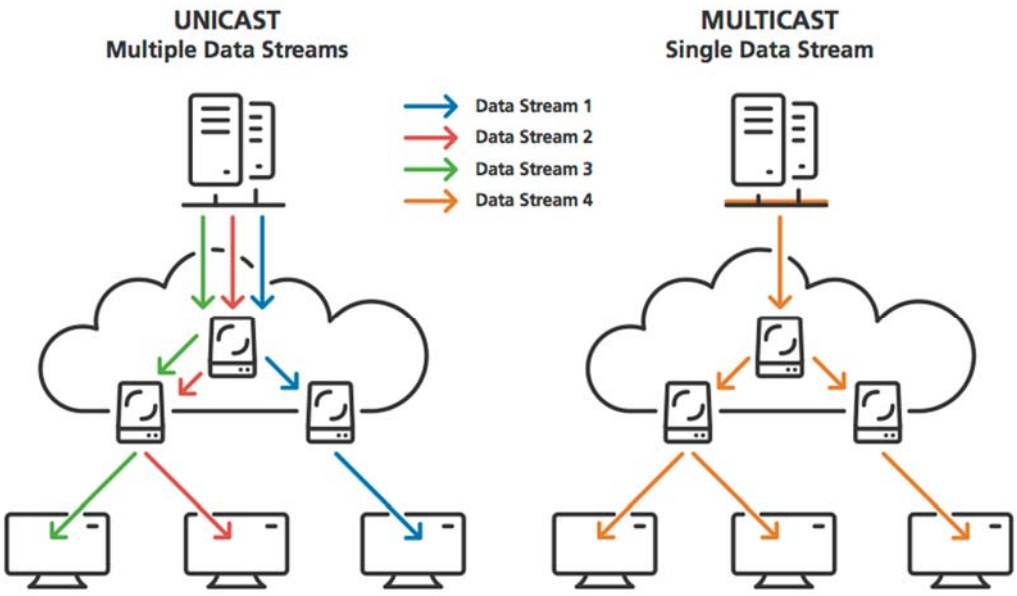

Figure 2 – Unicast vs. Multicast

Adaptive streaming is the concept of adjusting the streamed media to the needs of the current client by enabling the client to select a media representation with appropriate spatial resolution and bitrate for the current given network connection to ensure a continuous, non-sticking media playback with best possible quality. Therefore, the media content needs to be available in different quality levels constituting different available bandwidths. They are called media representation and traditionally range from small spatial resolutions and bitrates for mobile delivery to full high definition media representations. This allows to distribute e.g. maximum resolution, bitrate and fast startup to IPTV Set-Top-Boxes that are connected via Ethernet or via a stable home WiFi connection, while providing lower resolution and bitrate streams to second screens that are currently being used in a weak WiFi or in a mobile (e.g. 3G) network.

To allow a smooth switching between the different media representations and a seamless media playback at the client, the content is split into small segments of 2-10 seconds for each quality level containing one or multiple fragments. All current adaptive streaming technologies use media that is represented in a fragmented format to allow the client to effectively fetch a new media representation after a switching event through e.g. increase or decrease of the available bandwidth. Therefore, each representation is split into corresponding fragments that represent specific ranges of the media timeline. As a result, adaptive streaming technologies as HTTP Dynamic Streaming (HDS), HTTP Live Streaming (HLS), Smooth Streaming and MPEG DASH (see Figure 3) provide mechanism to deliver live and on demand video using HTTP unicast in an effective manner.

Furthermore, **streaming over HTTP perfectly supports the possibility of caching media data using Web caches**. Both the delivery of Live-TV and on demand media content benefits from caching mechanism. Well placed Caches can significantly reduce load on the backbone, especially during peak times when many users consume the same content. These edge serves are equipped with maximum I/O performance to serve content to a maximum of users by simultaneously discharge the original server´s load. State of the art

content delivery networks (CDNs) also follow this concept to hide load from origin servers, balance network traffic between multiple caches and relay servers.

Besides the described effective unicast approach, there are several other solutions under evaluation by CDN providers using e.g. multicast for inner-network content distribution. These approaches might be useful in special settings to deliver live content, but also massively increase the complexity of the given system. Converting between multicast and unicast, chunking/on the fly and translating of content on the edge servers requires additional hardware and ultimately increases costs.

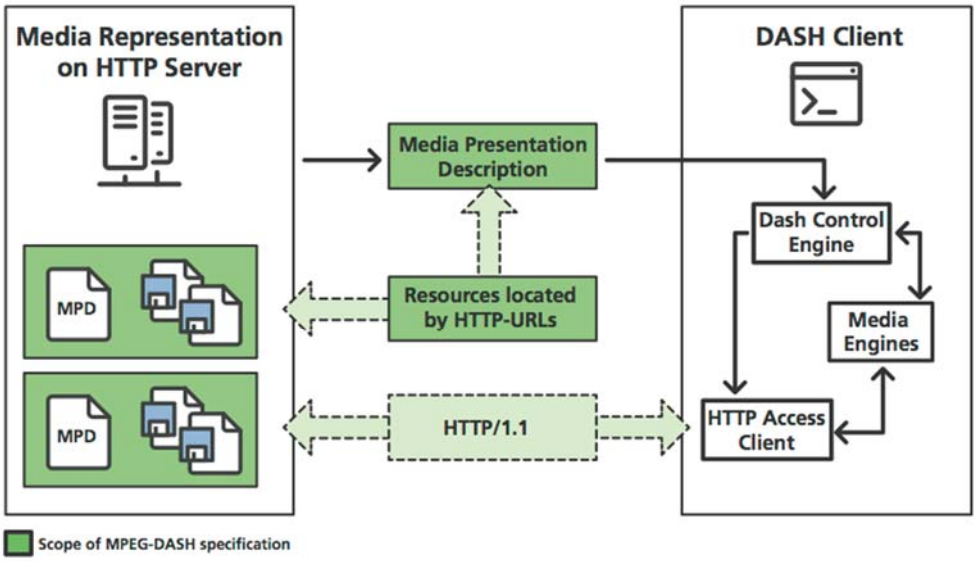

Figure 3 – Scope of MPEG-DASH

Building an E2E video platform using unicast delivery

As shown in the previous sections, **HTTP based adaptive streaming over unicast builds the foundation for new IPTV and OTT video services**. Figure 4 depicts a highly optimized system setup for such a Unicast IPTV / OTT video solution comprising of ingest servers, storage, encoders, transcoders, a video middleware as well as direct peerings with ISPs and an external CDN to **deliver live and on demand video via HTTP adaptive streaming over unicast to a wide range of clients**. The ingest servers receive source signals from e.g. satellite or via IP and feed the signals into the encoders where each stream is encoded to H.264 in highest bitrate and subsequently segmented. The segments are packaged in a universal format and stored in highest quality for further processing, catchup and individual recordings via network PVR functionality of clients. Translating of live and on demand segments to smaller bitrates and spatial resolutions is done by the Transcoder farm on the fly. In a subsequent step, the segments are packaged (muxed) in the appropriate format relying on the adaptive streaming format that has been requested by the client. Finally, the playlist or manifest files that describe the media representations are generated.

Additional steps are the encryption of media segments, access control and caching of fragments. To deliver streaming content to requesting clients, content delivery servers (origins) are connected through direct peerings with ISP networks. Established CDNs can be easily leveraged as backup routes or to compensate traffic peaks if needed. **Additional simple Web caches can be integrated in strategic spots of the ISP network to significantly reduce load on the backbone**. This does also apply for managed networks e.g. within the network of connected ISPs.

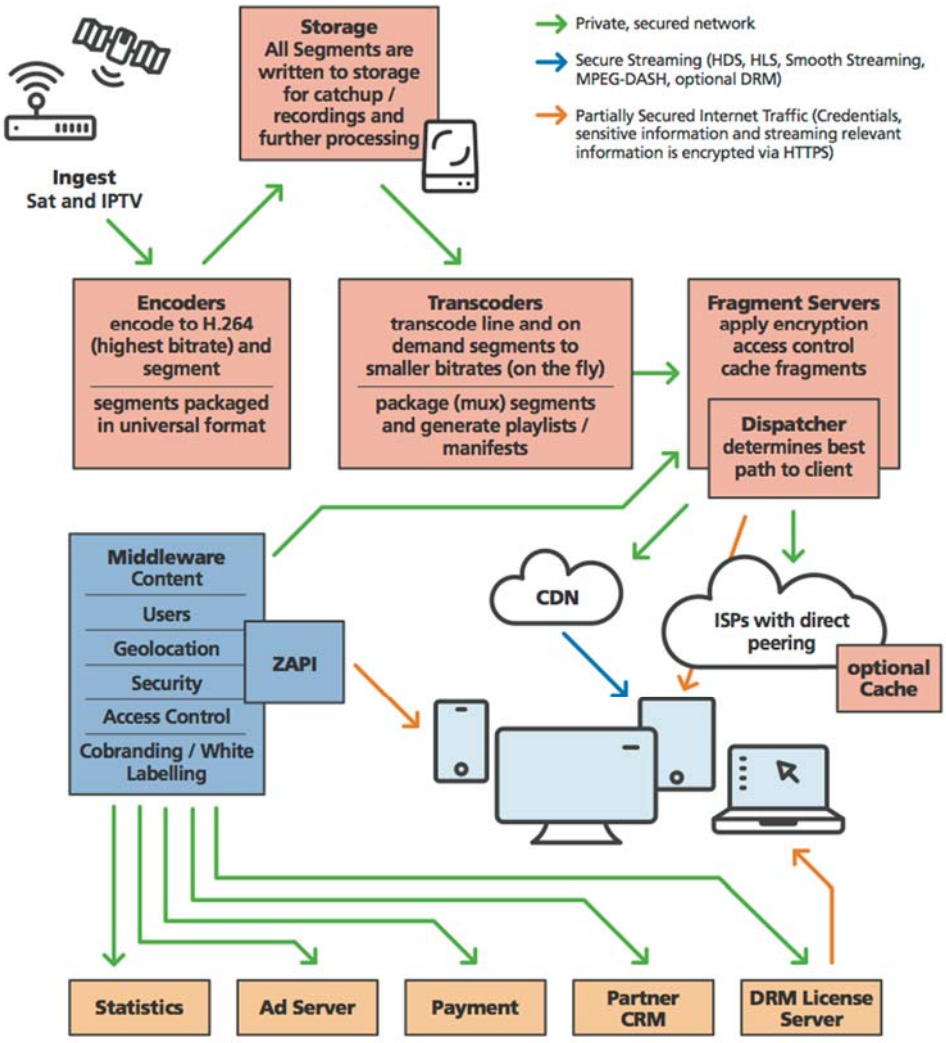

Figure 4 – OTT video service overview

As **all components are based on standard of-the-shelf hardware** running the different functions as software components, **cost-effective future extensions, scalability and flexibility is one of the key benefits compared to traditional solutions**. Caches and edge servers handle the increasing demand for bandwidth. Despite the resulting increase of unicast traffic in the network, the load can still be managed effectively with the same caching mechanisms. This fact is being favored by the development and introduction of next generation networks, which are built for Tbps network throughput as well as the introduction of next generation video codecs as e.g. H.265. Current codecs typically allow for a video quality comparable to traditional DVB quality with 1.5 Mbps for standard definition or 3Mbps for high definition content – new codecs will likely cut that in half. Unicast IPTV setups where the network operator leverages his own network and bandwidth, potentially in combination with caching servers, clearly allow for even higher bitrates, especially for First Screen IPTV services.

Summary and Outlook

To sum up, unicast IPTV services (live and on-demand) guarantee the same high quality user experience as traditional multicast-based architectures when leveraging appropriate technology and techniques.

First Screen IPTV services delivered over unicast quality-wise benefit from direct network peering with the network operator. Furthermore, the network operator is able to prioritize the network traffic that is caused by the IPTV service.

HTTP Adaptive Streaming is the foundation for multi-screen video delivery. By taking advantage of existing technology all major devices (e.g. second screens) and platforms can be reached – without any special hardware. Moreover, streaming efficiency and scalability can be significantly increased using strategically positioned Web caches.

In combination the aforementioned techniques lead to the possibility of streaming at maximum bitrate and quality, while lowering complexity and costs compared to traditional multicast-based architectures.

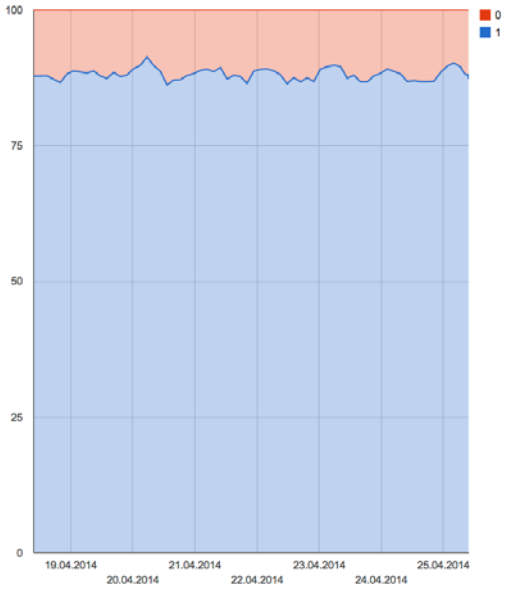

Figure 5 – Maximum bitrate graph

Figure 5 depicts a real data analysis provided by Zattoo. Over a period of a week more than 80% of the users of the OTT distributed B2C Zattoo service were able to consume the streams at the best possible quality level. Optimization in the delivery architecture (Web caches and peering), improvements in bitrate switching algorithms and developments in emerging standards such as MPEG DASH will lead to even better numbers. Even today, in B2B co-operations where Zattoo leverages direct network peering to hand over ready-to-distribute unicast streams to network operators, close to 100% of users are able to consume the maximum bitrate streams when using the service within the operator's network.

The following testimonials are provided by network operators that use Zattoo technology:

Andreas Cavegn (Product Management, Telecom Liechtenstein AG, Vaduz) on reasons for using Unicast for IPTV:

„Telecom Liechtenstein already deployed a Unicast IPTV Solution in 2009 and is now in the process of rolling out a new Unicast IPTV solution which will be fully hosted by a technology partner. This flexibility is only realistic using unicast technology, as no special hard- and software in the network and at the client level is needed. Linear Live TV consumption is decreasing in Liechtenstein like everywhere else. Time Shifted Live TV, Catch-up TV, and VOD are gaining importance. Therefore, even today Multicast technology does not have any relevant advantages and we expect this trend towards unicast to continue. Dependency on Multicast enabled devices would limit flexibility in the product offering. With our Unicast solution, a wide range of devices can be supported and a true Multiscreen experience can be created for the viewer.

With the expected usage and load on the backbone, it is perfectly feasible to support a Unicast deployment in the Telecom Liechtenstein Network. Multicast would bring added complexity to network infrastructure and operation, which – in a network of Telecom Liechtenstein's size – can't be justified."

Romain Lonfat (Head of Interactive Television, netplus.ch S.A., Switzerland):

„The peering we have in place today e.g. with our technology partner Zattoo for our own unicast Mobile-TV service, has several key advantages for us. Firstly, we get access to high quality video streams without depending on external content delivery network providers (CDNs). Secondly, we don't have incremental cost for the consumption of TV content as we leverage our own network. And last but not least, we ensure that the subscribers of our Mobile-TV service who are connected to the internet directly through netplus.ch will get high quality streams at any time of the day. This is the case even at peak times as the peering will make sure that the data will only transit on our managed network on which we have different priorities (QoS) depending on the services and the contents.

The overall quality thus does not depend on delivery anymore but we can set a level of quality depending on the devices covered. Today, we provide e.g. HD channels with a maximum profile at 3Mbit/s (ideal for PC and tablets) but we can easily increase that quality and bitrate if we need to address TV sets."

Matthias Grewe (Founder and CEO abox42 GmbH, Karlsruhe):

„As a STB provider to network operators and ISPs in Europe and beyond, we see a strong trend for IPTV solutions leveraging the power and the advantages of Unicast distribution. Especially for 2nd and 3rd tier operators, Unicast IPTV is highly attractive as it suddenly makes major hurdles and sources of complexity disappear. Most importantly, with a unicast IPTV there is no need to set up and operate extremely complex and costly Multicast networks. Quality of service is not an issue in this setup. On the contrary, with the use of the own managed network for Unicast distribution, a Unicast TV service clearly matches the quality of service of Cable and Satellite TV. Plus, the network operator can even outsource the entire TV service to an experienced TV service provider who then hosts the TV product and service. This for the first time allows for a rapid and cost effective rollout of an advanced multiscreen TV service for 2nd and 3rd tier network operators. At abox42, we are already involved in successful projects of this type."