Delivering IP to All Screens

A technical paper prepared for the Society of Cable Telecommunications Engineers
By

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Overview

Traditional Television

The service delivery of television over wireline telecommunication has a well-established story:

- Cable operators have been using dedicated RF frequencies over coax cable for many years to transport analog or digital TV signals using MPEG-2 compression over broadcast.
- IPTV operators started in the late 90s, with the first bulk of worldwide deployments occurring between 2005 and 2007. This was made possible with the emergence of DSL and H.264/AVC technologies using a fully switched IP (multicast) delivery mechanism.

The incentive to build the required network infrastructure to deliver the service was fairly straightforward: provide an exciting TV service (large lineup, HD video, VOD), alongside voice and Internet offerings. The corresponding ARPU made it not only worthwhile, but also opened up the ability to compete for new subscribers against traditional mediums such as terrestrial and satellite.

Putting it together required a fair amount of work to find and manage a complete ecosystem solution:

- Content rights
- Video headend
- UI/middleware
- DRM
- VOD
- Hybrid fiber coax /access network
- STBs (set-top boxes)

At least it was a walled gardened environment: all aspects of the solution were under the operator's control. Especially the STB, which was the main and unique link between the outside world and the TV set.

Figure 1 Traditional linear TV: Designed for the first screen

Then Came Multiscreen

In the last few years the so called “multiscreen” service delivery of linear and on-demand content to mobile and web devices has seen the build up of a unicast infrastructure. It has been, for the most part, a side-card or silo deployment for many reasons, including the lack of real or perceived ROI and a widely changing set of technical requirements, formats, and standards (mostly driven by the end devices).

In all cases, due to the nature of the end devices, a one-to-one network connection is made for each viewing session: this is unicast, and it is not the most efficient use of bandwidth since it is unique per each user regardless of what is being watched. Unicast streaming relies on the widespread HTTP streaming protocols supported – usually natively – by the second-screen devices (i.e., Apple HLS, Microsoft Smooth, Adobe Flash to name a few).

Making it a complete ecosystem solution also required quite a bit of work:

- Content rights for the second screen have been tough because this was not included with the rights previously secured for traditional broadcast. That led to implementation delays and the need to develop special blackout workflows for multiscreen. Additionally, content rights for the time-shifting of TV using the cloud have been a monkey wrench in the development of that service.
- The video content preparation headend required different transcoding formats at different bit rates (this is called ABR for Adaptive Bit Rate); and also a specific packetization for each end device.
- DRM, of course, has been different, but also not always native to the end devices.
- The UI/portal and necessary custom players on end devices have required extensive outsourcing in order to have the right protocol and DRM supported on end devices.

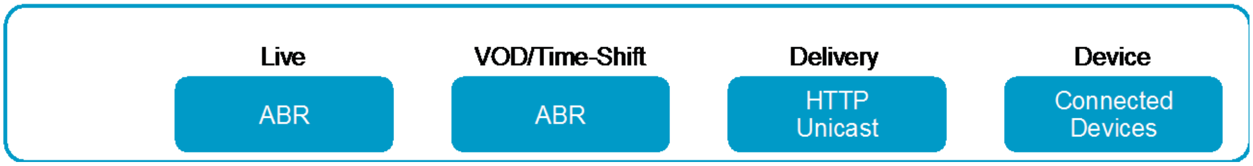


Figure 2 Multiscreen (AKA TV Everywhere) added later as a silo

Now Things Must Evolve

The customer expectations for TV service have outgrown the traditional linear 1.0 delivery model. Today’s consumers want a unified and intuitive TV experience, anywhere, anytime.

It is now time to look forward to a new type of service delivery solution for wireline delivery. We call this IP to All screens or IPTV 2.0.

Contents

CHALLENGES IN THE GROWTH OF CURRENT ARCHITECTURES

Focusing on delivering the next-generation TV service experience is great but there are many challenges to address in order to make it a viable business, especially when trying to grow the service offering on top of current architectures.

Bandwidth

Operators are challenged to deliver more video to more places than ever before. This may include sending more streams per home, reaching the subscriber farther than before, such as outside the managed network on the open Internet, on a cellular 3G or 4G/LTE network, and even on bandwidth constrained wireline (e.g xDSL).

Operators are challenged to free up bandwidth on their core network and last mile to make room for more data traffic.

Operators are challenged to provide the best video quality experience, which is a key criteria monitored by subscribers, the press, and competitors alike. High-quality video is important on the first screen, and on the second screens inside or outside of the managed network.

The remedy here is unquestionably to use of the most efficient video compression possible and also increase it, over time, wherever possible. The codec might be different between the various delivery networks, so the headend should be fully agnostic to the codecs and the transport protocols.

Explosion of Formats (BYOD)

There is simply no denying that the wave of consuming TV on second screens has broken the walled-garden status quo of the last 20 years. Now operators must worry and contend with a BYOD (Bring Your Own Device) trend that is increasingly difficult to manage:

- Different vendors
- Different protocols
- Different networks (wired, WiFi, 3G/4G)
- Built-in IP unicast streaming reception only (rather that DVB-S/ DVB-C / DVB-T broadcast)

The only scalable approach is to embrace the native HTTP streaming technologies, which are all supported on those devices one way or another. Apple HLS, Microsoft Smooth Streaming, and Adobe Flash do provide a nice coverage of all those devices.

MPEG-DASH is also being pushed forward by the industry and broadcast community to rally all of the above under one banner, once and for all.

The upside is that the service provider does not incur the purchase cost of those devices; the subscriber happily buys it.

BYOD is driving the architecture and not only does one need to realize this, but one must embrace and figure out the smart way to migrate to IP-based HTTP streaming. In North America, TWC has already deployed its TV service on a Roku box and has also started to offer a Fan TV STB to it subscribers.

Time-Shifting the TV Experience

Operators must deliver the highly appealing functionality of time-shifted television in all its flavors:

- Pause-live
- Start-over
- Catch-up aka retro EPG
- PVR recording for all customers, to all screens and on any network

The way to tackle all the variants is to build the most efficient infrastructure possible. It may turn out to be slightly different based on the exact network architecture and CPE diversity. What is clear is that the trend of building video storage into STB is reversing due to the costs issue, and mobile devices usually do not come with any real video storage either.

While the current status in the United States for a network PVR service (per the Cablevision ruling) is that of a “copy-per-subscriber,” it is expected that both the legislation and content agreements will evolve over time; therefore, the solution to be deployed by an MSO should be able to provide an optimal ratio of price/performance in shared copy and private copy modes.

Recent trends favor a shift of the video storage, transcoding, and caching inside the operator’s network, which also lines up with the C-level desire to focus the capital expenditures away from CPE and toward the network infrastructure.

Strategize CAPEX and OPEX Spend

The existing broadcast model and mentality of “silo”-ing every delivery mechanism and sometimes service offering is just not built to withstand the major changes and challenges incurred by the recent shifts highlighted above.

On CAPEX it is more favorable to invest on the network infrastructure rather than CPE. It is simply because the network throughput at all stages is the business enabler, regardless of where the revenue mix comes from in the future, either from data services, TV services, or from new services (e.g., security, medical, home automation). On the other hand, the CPE category, while necessary, is bound to continue its rapid lifecycle and is competing with technologies outside the service provider's control.

Regarding OPEX, this major technology shift is an opportunity to look at the network delivery from a TCO perspective and figure how to streamline operations and prepare for the future. Not only because of time to market, but also because new technology encompasses evolutions we can't quite predict. Meaning that within the expected amortization window of the initial CAPEX spend, there will be a technology change required. The future is going to be friendlier to a virtualized video infrastructure on a private datacenter or private cloud.

THE EVOLUTIONARY PATH OF TV DELIVERY

IP to All Screens: The Long-Term "End Goal" Architecture

With all the above considerations in mind, here is a vision of the end goal architecture that can meet all the requirements.

- Live TV channels are compressed with the best AVC and HEVC techniques across a wide range of resolution and bitrates using ABR in order to serve all screens and all networks.
- VOD and time-shifted services also migrate to same techniques as live, that is AVC/HEVC compression and ABR.
- The delivery, at least as seen from the end device, is a HTTP unicast streaming session (there may be different core network strategies).
- The end devices all support ABR HTTP streaming regardless of which screen they serve, regardless of which network they're on, regardless of who owns it.

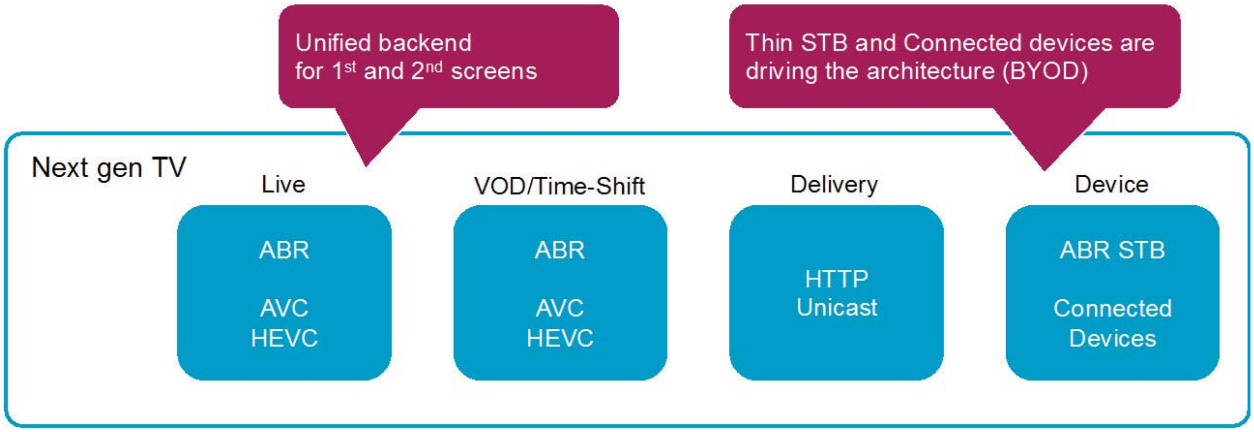
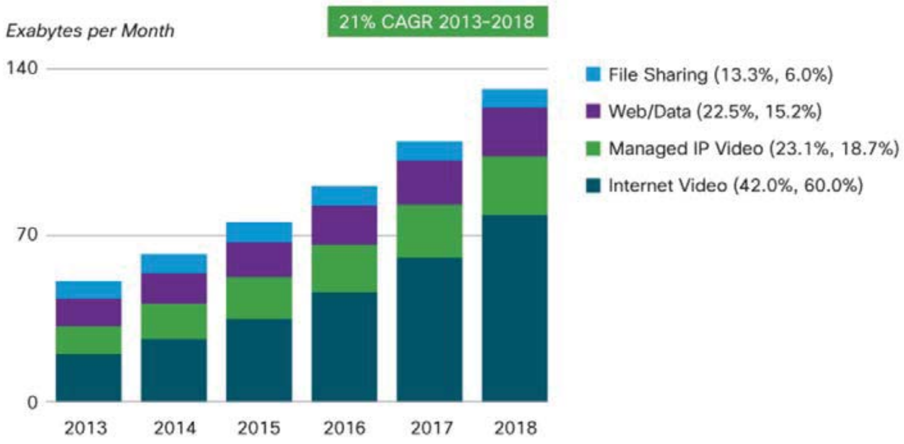


Figure 3 Long-term vision for an all-IP infrastructure

This architecture is very much a statement that the recent streaming technologies have won the battle and that video traffic over IP networks is on a relentless path.



Source: Cisco VNI, 2014
The percentages within parentheses next to the legend denote the relative traffic shares in 2013 and 2018, respectively.

Figure 4 Global IP traffic by application category [2]

Architecture Benefits

The benefits of the above envisioned architecture are very obvious:

- The same infrastructure serves first screen TV and second screens
- A streamlined architecture that is future proof in terms of screen, network, device: it allows fast and seamless deployments of new services and monetization opportunities
- The solution is optimized for CAPEX and OPEX: only ONE infrastructure to manage

It allows a smooth migration of the currently existing service:

- A phased approach is possible regardless of the initial architecture, allowing organizations to strategize CAPEX spend over whatever period of time
- In some cases it is a migration toward an already existing OTT HTTP infrastructure and ecosystem
- One HTTP-based backend for VOD and time-shifted TV to all screens and all networks
- HTTP-based protocol are “CDN-friendly”
- HTTP streaming allows organizations to reach subscribers on new networks such as 4G/LTE, 5G and fully OTT on the open Internet
- Live television can stay on IP multicast until a new transport protocol arrives (no extra CDN capacity to plan)

The architecture is friendly for deployment on an all software infrastructure; it can migrate to virtualization on blade centers or possibly in the cloud.

BUILDING A MIGRATION PATH FOR THE ARCHITECTURE

Starting Point: The Classical Overlay Architecture

The architecture functional diagram below depicts a classical deployment representative of most service providers.

The cable QAM modulation or the ADSL/fiber layers have been abstracted for simplification purposes, as it has no impact to our exposé.

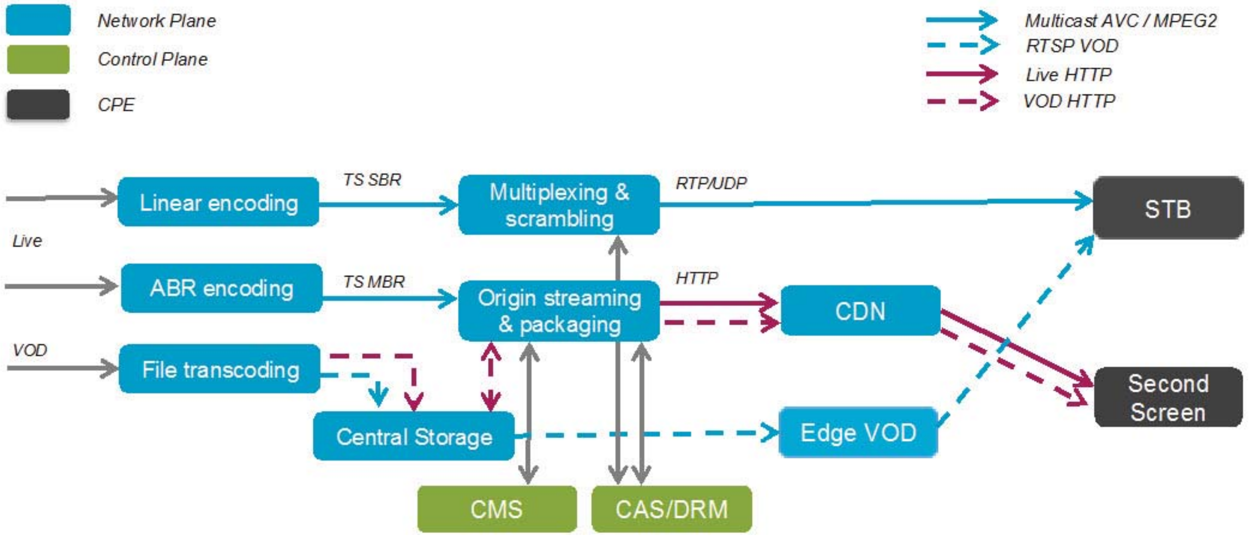


Figure 5 Classical broadcast and multiscreen overlay solution

One will notice how both live and VOD have different solutions depending on which screen they are serving, and also which network (abstracted here).

Unifying Live Encoding

One of the first and easy migration opportunities is definitely the back-end live compression unification for live broadcast and live multiscreen.

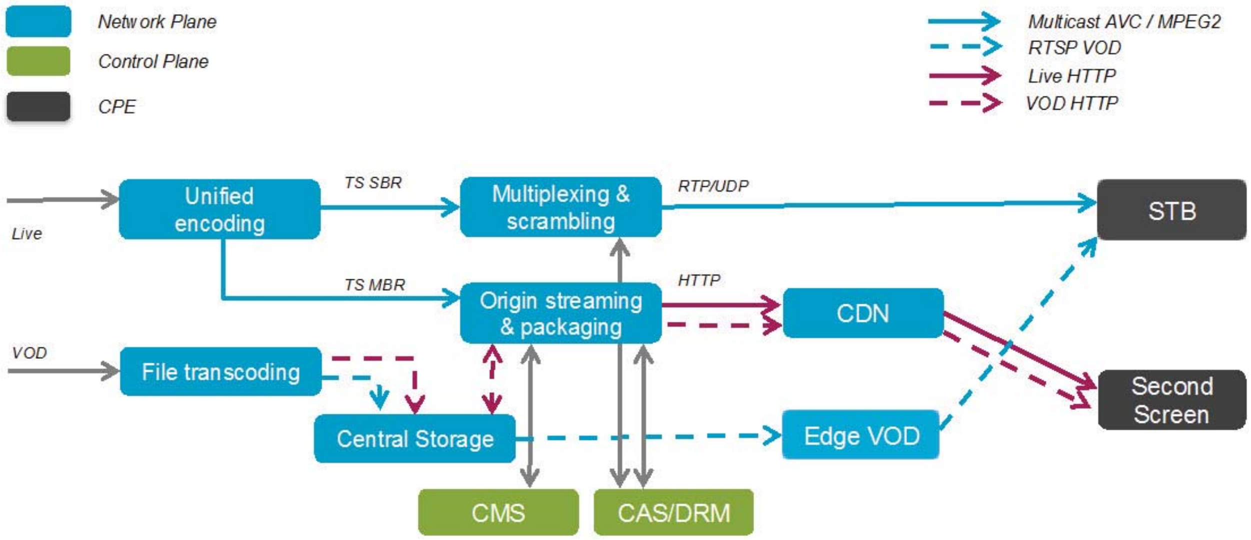


Figure 6 Unified live encoding solution

Here is a sample of the expected benefits of such a move:

- Improve TCO with a combined broadcast and multiscreen headend
- Leverage the investment cycle to migrate to the last MPEG-2 and AVC technologies to reduce video bandwidth
- Keep the same architecture
- Keep the same STB
- More streams per home
- More room for data
- Leverage the investment cycle to migrate to a software-defined virtualized video infrastructure (local datacenter, or even private cloud)

Unifying VOD Delivery

The other early migration opportunity is the VOD back-end and delivery workflow unification for first and second screens alike.

The RTSP protocol is getting old and is not forward looking. What is required in this step is also to migrate the first screen STB software to support VOD from HTTP inputs. Obviously, not all STBs may be able to support and or to migrate at once. This move can follow the existing CPE deployment and software lifecycle.

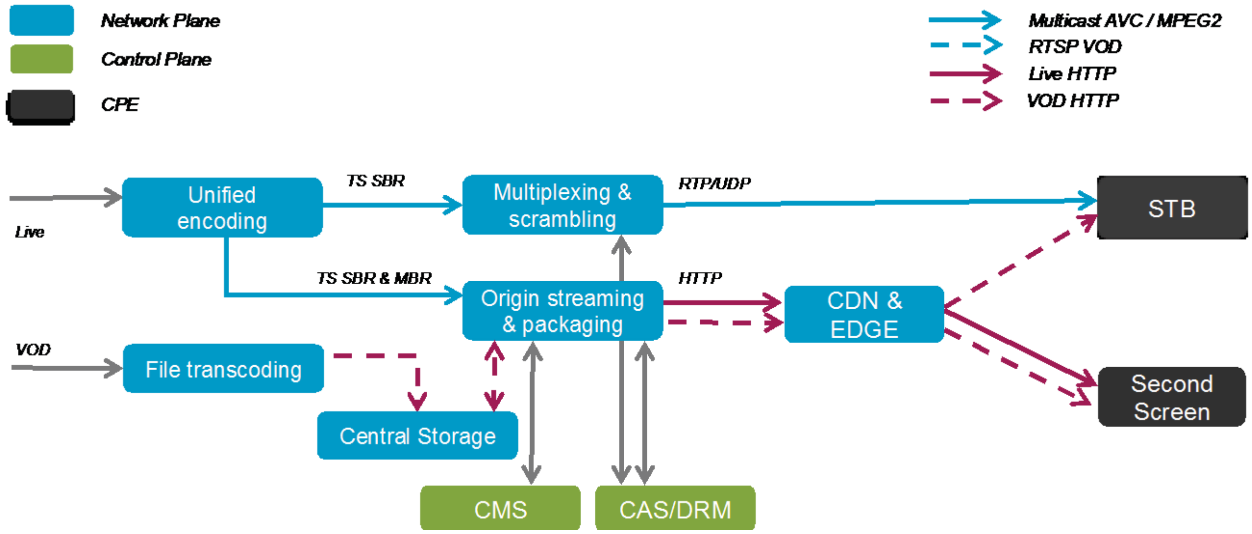


Figure 7 Unified VOD solution

Here is a sample of the expected benefits of such a move:

- A fully consolidated VOD infrastructure
- True "all screens" delivery
- A deeper library
- The unification has the tremendous upside to also create a fully time-shift capable delivery system based on HTTP. Reuse or build once for HTTP and use it across all networks and all screens!
- Repurpose existing edge VOD servers (caching capabilities)

Unifying Delivery to HTTP

The big migration step is to move all video delivery to HTTP steaming over IP. It doesn't have to happen overnight, and nor should it.

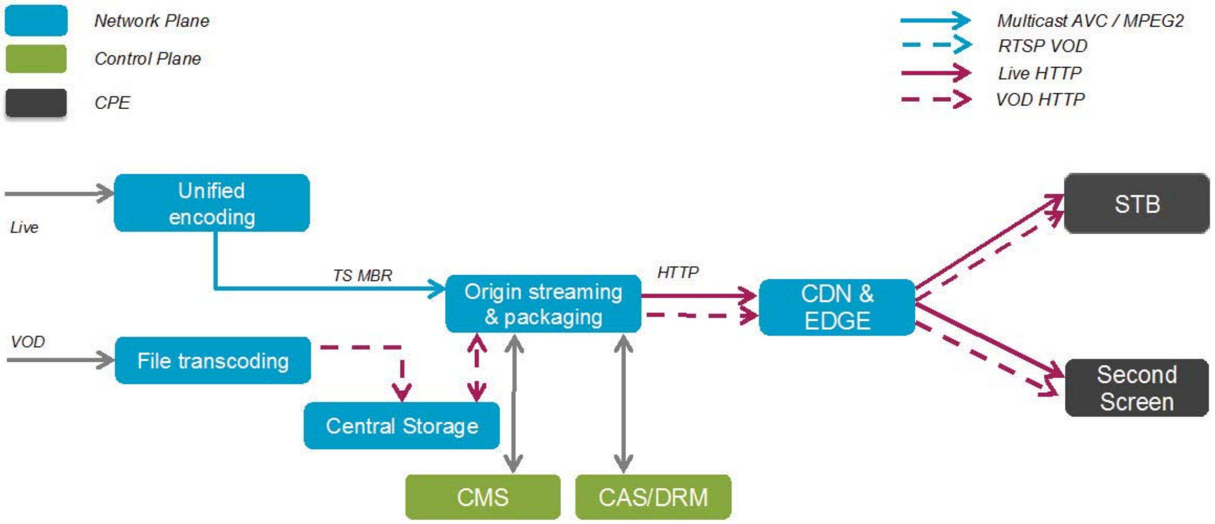


Figure 8 Unified HTTP-based delivery

Here is a sample of the expected benefits of such a move:

- Unified delivery for all screens
- Unified delivery for all networks: cable, DLS, fiber, OTT, 4G/LTE/5G,
- Ability to support any device
- Ability to seamlessly bridge on-net and off-net for pure OTT delivery
- Simplify the operations and improve TCO with a combined broadcast and multiscreen delivery

From the end device perspective this architecture is quite elegant because it is seamless. It is always a unicast HTTP connection regardless of the network. It is fully transparent, and the subscriber is happy because honestly he does not want to know about the underlying details.

Scaling the Live HTTP

The main objection of an all unicast delivery is that it will essentially break the network. The most easily identifiable challenging use case is live TV delivery. If 1 million subscribers watch the same HD live sports channels then the theoretical unicast bandwidth required to serve all those subs is a mind boggling 1M x 5Mbps = 5,000 Gbps sustained.

Table 1 compares the traffic required for a second screen application versus what is need for a first screen application, assuming egress of 1G/s for a second screen origin server and 10G/s for a first screen origin server. Session count for second screen is an average of measured numbers in operators' deployments.

Service	**2nd screen**	**1st screen**	**Increase**
1M subs	1M	1M	
Take rate	10%	100%	
Max Edge sessions	100K	1M	
Avg session BW	1M/s	5M/s	
Avg edge traffic	100G/s	5T/s	50x
Miss rate	10 %	10%	
Max Origin sessions	10K	100K	
Avg Origin traffic	10G/s	500G/s	50x
Edge cache egress	**10G/s**	**40G/s**	
# of edge caches	10	125	X12.5
Origin egress	1G/s	4G/s	
# of Origin	10	12.5	X12.5

Table 1: Traffic comparison between first and second screens

Looking at the table, we can safely say that there is more than 10X CAPEX increase when moving from second to first screen. We definitely need to find a more scalable way than just adding edge cache servers to stream Live HTTP.

While the caching topologies are getting better and smarter there is also another help on the way. The method is to use multicast transport inside the core network all the way to the “edge” as close as possible of the end-user. This is where a multicast to unicast conversion takes place and a final HTTP packaging. The IP to all screens or IPTV 2.0 initiative is naturally designed to leverage up-and-coming, highly scalable architectures that enable live ABR across either QoS networks, with multiple technology options:

- multicast conversion over QoS network
- multicast transport with edge packaging
- multicast over best effort Internet
- multicast over automatic multicast tunneling (AMT) network

We describe in table 2 the different options

Items	Multicast over QoS	Multicast transport/Edge packaging	Multicast over Internet	multicast over AMT
Qos NW	Yes	Yes	No	Yes
Specific NW	No	No	No	Yes
Specific client	GW / Client	No	Yes	No

Table 2 Multicast ABR technologies

In the section below the various architectures associated to the different options are described.

Multicast conversion over QoS network

Figure 9 describes the multicast over QoS network scenario: content is prepared and output by the origin server in unicast to a multicast converter that will carry live traffic over a multicast capable network. The edge cache delivers multicast to the gateway that will do the multicast to Unicast conversion. CableLabs is currently standardizing the live HTTP scaling, based on the HTTP to multicast conversion using the NORM protocol [4], other techniques like 3GPP FLUTE can also be used to carry multicast.

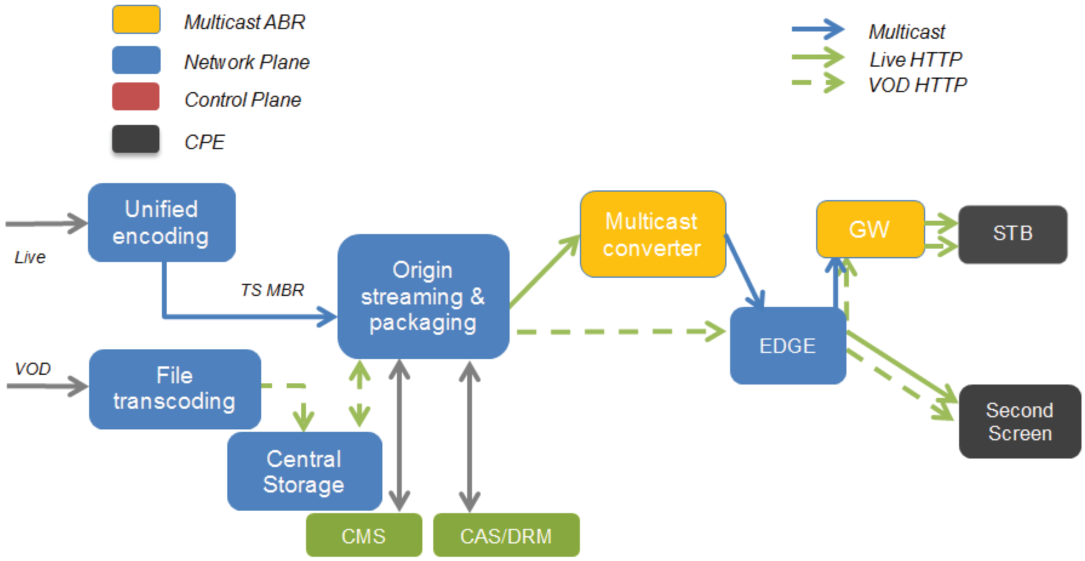


Figure 9 Multicast over QoS network

Multicast transport / Edge packaging

Figure 10 describes the multicast transport/Edge packaging scenario: content is prepared and output by the origin server in multicast to a multicast capable network. The edge cache delivers Unicast to the gateway.

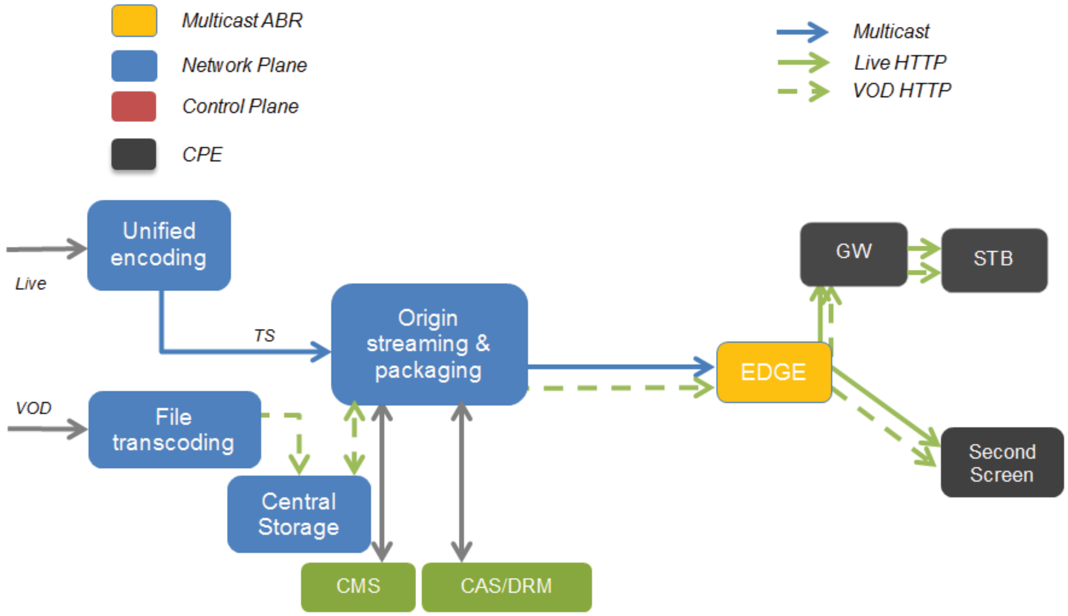


Figure 10 Multicast transport / Edge packaging

Multicast over best effort Internet

Figure 11 describes the multicast over Internet scenario: content is prepared and output by the origin server in Unicast to an overlay network over Internet that is using multicast and other technologies to scale the Live ABR distribution. The edge cache delivers Unicast to the gateway.

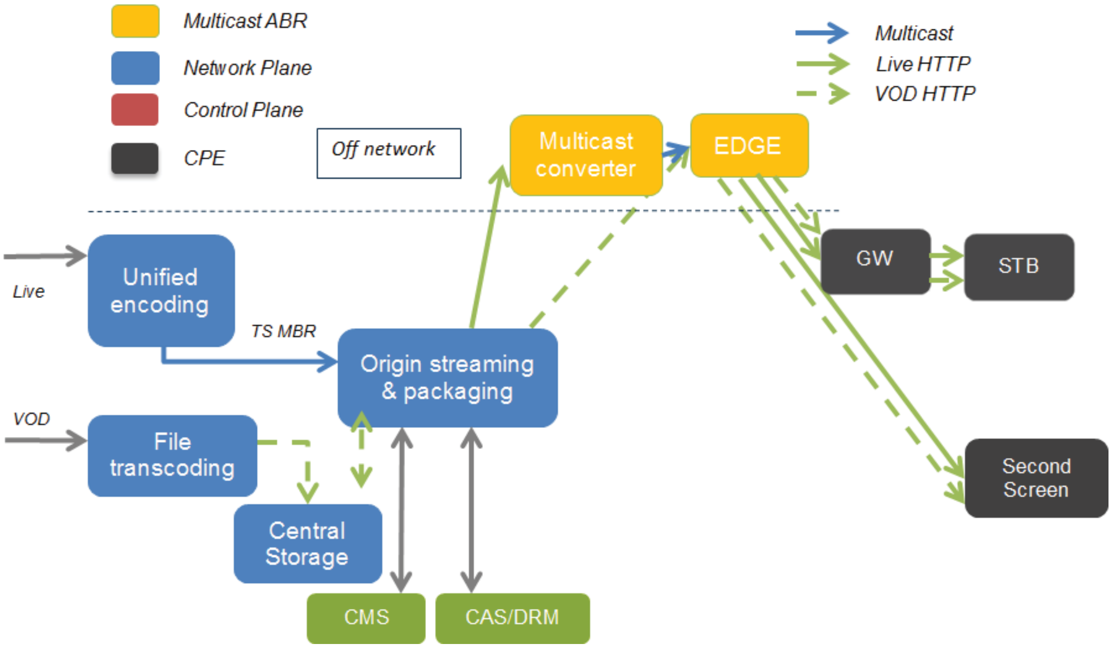


Figure 11 Multicast over best-effort Internet

Multicast over AMT network

Figure 12 describes the multicast of over AMT scenario: content is prepared and output by the origin server in Multicast to a multicast AMT capable network. The Edge cache receives multicast and transforms it in Unicast to the gateway.

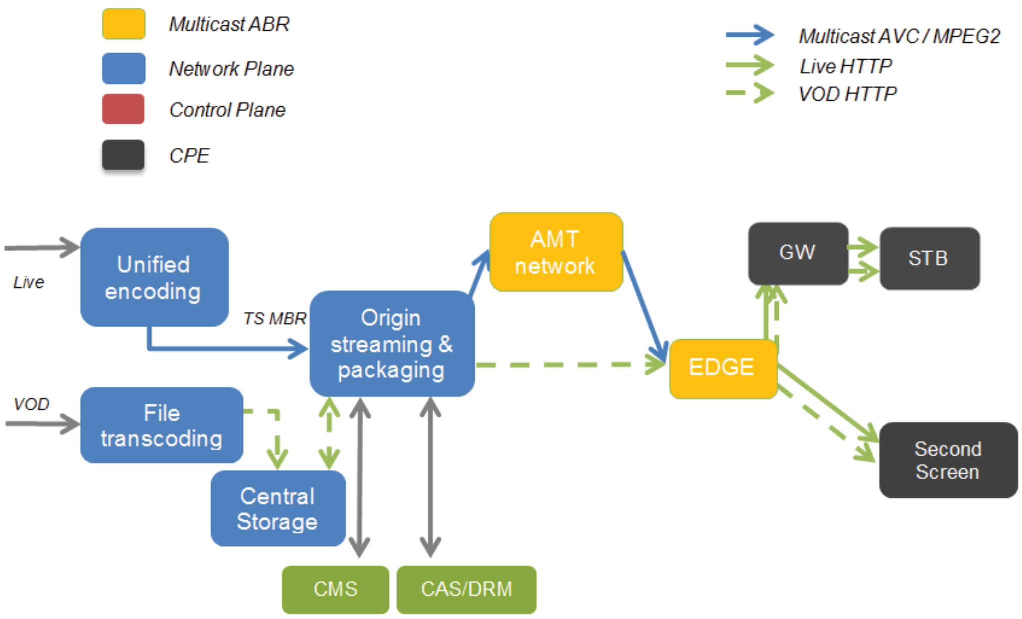


Figure 12 Multicast over AMT

Leveraging HEVC Compression

Finally, one of the major migration steps is to find a way to deploy the new HEVC video compression standard. It is now reasonable to expect a 50 percent video bandwidth reduction, especially for the highest profiles where high bitrates are still the norm. IPTV operators nowadays have a target of 2.5Mbps for the premium HD video, so this is very exciting!

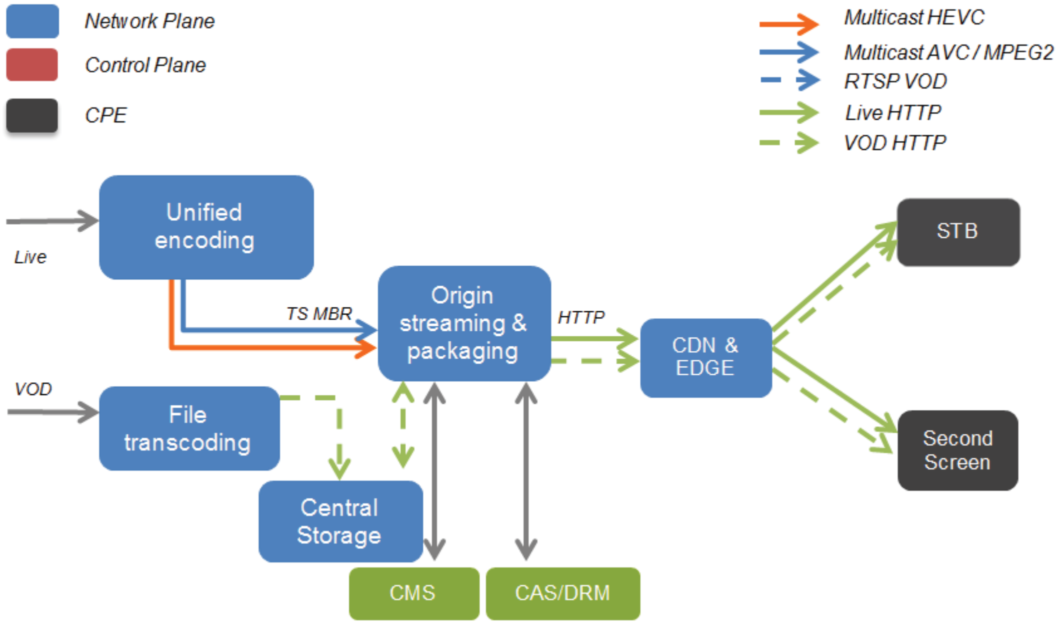


Figure 13 Enabling HEVC

Here is a sample list of the expected benefits brought by HEVC adoption:

- Lower unicast video bandwidth
- Lower broadcast video bandwidth if used on a legacy network (e.g., QAM, DSL etc.)
- Significant core network bandwidth savings
- More streams per home
- Better video quality for users unable to receive today's high HD bitrates
- Less storage for time-shift TV
- Ultra HD/ 4K delivery

Perspective from Operators

There is already strong market evidence that an IP to all screens approach is the way to move forward.

One example is the service launched by Totalmovie, a Grupo Salinas company and leading video streaming and over-the-top service. Totalmovie launched in the second half of 2013 [5] a live OTT multiscreen streaming service in over 40 countries in Latin America and the Caribbean, including Brazil. Using advanced ABR (adaptive bitrate) and multicast technology they enable customers to view 64 high-quality SD and HD channels on a wide range of devices including TVs, set-top boxes, tablets, and smartphones. This is the first multi-country service in Latin America to combine live TV and VOD. Recently, Totalmovie's parent company decided to shift to pure a white label strategy to provide a worldwide cloud streaming platform [6].

Another crystal-clear example that the industry is rapidly moving in this direction is the RDK (Reference Design Kit) initiative led by a joint venture between Comcast Cable, Time Warner Cable, and Liberty Global. "*The RDK is a pre-integrated software bundle that provides a common framework for powering customer-premises equipment (CPE) from TV service providers, including set-top boxes, gateways, and converged devices. The RDK was created to accelerate the deployment of next-gen video products and services. As stated on the web site rdkcentral.com* [7] *"The broad purpose of RDK is to solve the problem of "the any's," (any content, any device, anywhere) and specifically "any device." It removes differences between custom/legacy platforms and "customer owned and maintained" (COAM) platforms, so as to treat consumer-purchased devices as first-class citizens in the cable ecosystem. It is also intended to bring the richness of Internet/IP content back to the TV screen."* Even BskyB, arguably one of the leading satellite pay-TV operators worldwide, is rumored to have taken a licensing interest in the RDK [8].

Conclusion

IP to all screens is but the realization that one needs to migrate the first screen legacy architectures in order to build a scalable, efficient, monetizable, first-class TV service.

Migrating to this new architecture is easier than one might think, with tremendous benefits awaiting:

- Single, unified platform for the delivery of IP video to all screens
- Fast deployment of new linear, VOD, and time-shift TV services for any screen
- Highly scalable, streamlined back-end operations
- Compatibility with RTP/UDP, as well as HLS, MSS, HDS, and MPEG-DASH OTT ecosystems
- Integration leveraging all industry-leading CMS, DRM, and CDN partners
- Flexible migration path, regardless of starting point
- Future-proof solution provides investment protection
- TCO-based approach is possible, for example, by choosing a software virtualization path

Acknowledgements

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Abbreviations & Acronyms

3G	3rd Generation
4G	4th Generation
ABR	Adaptive Bit Rate
ADSL	Asymmetric Digital Subscriber Line
ARPU	Average Revenue Per Unit
AVC	Advanced Video Coding
BYOD	Bring Your Own Device
CAPEX	Capital Expenditure
CAS	Conditional Access System
CDN	Content Distribution Network
CMS	Content Management System
COAM	Customer Owned and Maintained
CPE	Customer Premise Equipment
DASH	Dynamic Adaptive Streaming over HTTP
DRM	Digital Rights Management
DVB-C	Digital Video Broadcasting-Cable
DVB-S	Digital Video Broadcasting-Satellite
DVB-T	Digital Video Broadcasting-Terrestrial
EPG	Electronic Program Guide
HD	High Definition
HDS	HTTP Dynamic Streaming
HEVC	High Efficiency Video Coding
HLS	Hypertext Transfer Protocol Live Streaming
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
IPTV	Internet Protocol Television
LTE	Long Term Evolution
Mbps	Megabits Per Second
MSS	Microsoft Smooth Streaming
OPEX	Operating Expense
OTT	Over The Top
PVR	Personal Video Recorder
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
ROI	Return Of Investment
RSTP	Real-Time Streaming Protocol
RTP	Real-Time Transport Protocol
STB	Set Top Box
TCO	Total Cost of Ownership
TV	Television
UDP	User Datagram Protocol

UI	User Interface
VOD	Video On Demand
xDSL	x Digital Subscriber Line