12

OTT multimedia content delivery: a study

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In the last few years, the world has experienced an explosion of video content delivery over the Internet, using the so-called over-the-top model. More efficient video encoding, the wide spreading of broadband and the proliferation of Internet flat-rate plans are the main reasons for this evolution. Netflix is the major symbol of this model, with more than 100 million subscribers worldwide, and many others are willing to follow this example.

Keywords

OTT; Multicast; Software-Defined TV; CDN; Live Streaming; VOD; Timeshift TV

Introduction

Traditional TV services have substantially changed in recent years. Today, subscription TV services reach a large number of households, and IP-based delivery is gaining ground to traditional cable. Video-On-Demand (VOD) and timeshift capabilities are now widespread, allowing customers to get access to Digital Video Recorder (DVR) features and watch past TV programmes. More recently, global players like Netflix and others are operating a revolution, by providing TV contents (mostly on-demand) and leveraging their business in an OTT model strategy. Using the Internet and regional caching systems, they are able to reach customers in the global market, increasing dramatically their business at a very low cost. Simple delivery models combined with competitive subscription plans make services extremely attractive.

Today, each Altice operation runs its own TV solution, constraining synergies and precluding the group from taking advantage of scale. In a global environment, Altice faces strong competition from OTT players. In such a challenging environment, it is of vital importance to understand how a traditional telco can take advantage of OTT-like technologies to deliver TV/multimedia services, reducing costs and increasing profits. Furthermore, a large telecom group like Altice must take advantage of scale to find synergies, by unifying technologies and managing multiple operations in a convergent manner.

With this context in mind, and considering the fact that some Altice operations are experiencing exceptional transformations, it is important to understand the current trends of the TV and multimedia content delivery and define a unified strategy for the entire group. Recently, Altice Labs has been engaged in a study to elaborate on how we envision the TV/multimedia services of the future, considering two- and five-year timeframes, and proposing a strategy to lead this transformation.

To meet the requirements of future TV services, a new palette of emerging technologies needs to be addressed. Special remarks go to the cloud and software-defined technologies, which provide the flexibility and agility to efficiently run TV components, instantiating and scaling them, where and when required, adjusting the capacity to the current load. Other important topics are IP, unicast, open Application Programming Interfaces (API), micro-services, multi-access, or multi-operation.

This article starts by introducing the reader to the topic of TV/multimedia content. In the first section, it highlights the state-of-the-art and major future trends. Next, briefly identifies the relevant players in the delivery of TV/multimedia contents, comprising traditional telcos, technology vendors and OTT providers. In sequence, the proposed strategy is described, presenting the options layer by layer: presentation, control plane and media plane, for two- and five-year timeframes. Then, the article analyses pros and cons of using IP multicast or IP unicast to deliver live contents, using Portuguese and USA inspired scenarios. Finally, a brief conclusion is presented.

State-of-the-art and trends

In the last few years, the TV and multimedia sector has quickly evolved, changing radically the way people watch TV. New and richer user experiences, with higher quality, multiple screens, Internet-based, or cloud-based solutions, are some of the main trends.

Firstly, the **user interface** (UI) is changing and a minimalist look-and-feel is emerging, where content itself is the user interface. Big images and titles, large background areas and video overlay, are the preferred user interactions.

Multi-screen and companion devices are becoming increasingly popular, allowing users to watch TV on any screen (e.g. mobile, tablets, PCs). Users expect similar look-and-feel and the same set of features, no matter the screen they are using. Advanced features like moving the viewing from one device to another is a nice-to-have ability. The momentum for companion devices is also high, working as personal assistants for complementary actions like search or recommendations.

Users also expect ever increasing **video quality improvement**. 4K resolution is quickly becoming an industry standard, making it mandatory for top content providers to support this technology. 4K contents and devices are becoming available very quickly (e.g. PlayStation, Xbox One S, GoPro, iPhone). Soon, the 8K evolution will come to the market, as the technology is poking out.

In order to respond to these challenges, **TV platforms are already improving**, increasing performance, reducing costs and power consumption. Cloud solutions are becoming popular, supporting large libraries and massive streaming, even from long tail contents. Open TV platforms, like Reference Design Kit (RDK) or Android TV, are also rising, promising to change the vendor landscape in the near future.

New **business models** are emerging. Most of the traditional telcos started to provide OTT TV offers of their own (e.g. MEO Go, Verizon Go90) or reselling the service from OTT content providers (e.g. Vodafone/Netflix). Although OTT services deliver essentially VOD contents (e.g. Series, Movies), most of them are looking to introduce live streaming as the natural evolution (e.g. Apple, YouTube, Hulu). The Subscription VOD (SVOD) model with full access to all contents is becoming the rule.

In this context, **contents play a central role** in the ecosystem. Traditional TV providers are acquiring expensive rights for live sports. In the future, OTT players may strive for the same, although for example, Netflix has recently stated they will not make this move. The establishment of partnerships with big content providers becomes a strategy (e.g. Netflix with Disney), whereas in-house production is gaining momentum (e.g. Netflix, Altice Israel).

Legal changes can influence the way players act in the market, in particular in the European Union (EU) context. In February 2017, the EU approved the Portability of Services, meaning that subscribers from a member state must be able to access TV/multimedia services when travelling as if they were in their origin country (today, multimedia services cannot be watched abroad). This norm will take effect in the first quarter of 2018. Furthermore, the EU is pursuing the so-called “Open Audiovisual Market in Europe”, in order to break the Country Of Origin (COO) principle, allowing any provider from any member state to deliver TV/multimedia services to customers in other member states, overcoming the current legal barriers on content rights.

Relevant players

The TV/multimedia content delivery, traditionally managed by cable TV providers, involves today a set of players fighting for a piece on the global cake. The three major players involved in this market are traditional TV providers, OTT content providers and technology vendors.

TV providers

TV providers include the most traditional cable TV operators, who deliver TV channels using a Hybrid Fiber-Coaxial (HFC) infrastructure, and traditional telcos, delivering IPTV on copper (ADSL) or fibre technologies.

Most of the traditional TV providers are introducing mobile OTT operations, providing their customers with multi-screen experiences, either by developing their own solutions, powered by technology vendors, or in partnership. The service, look-and-feel and content (e.g. VOD, channels) and features (e.g. live, DVR, timeshift TV), try to be unified with the traditional residential TV, although in most cases, there are some gaps.

Some TV providers open the service to external customers, but the vast majority only provide the service for their residential customers as an add-on. In a few cases the service is free, supported by advertising, but in most of the cases, there is a monthly fee.

When telco operators provide TV/multimedia services, usually they do not charge for the traffic for the mobile bandwidth consumed, thus promoting the use of their own services against competitors, like Netflix.

Examples of traditional TV providers that created their own OTT service as a complement of their residential offer are Altice PT with MEO Go, SFR with SFR TV/PLAY, Swisscom with TV Air, Verizon with Go90.

Technology vendors

There are several traditional TV/multimedia technology vendors well positioned in the market, advertising very similar selling points. All of them announce the support of high video quality (4K), TV anytime and anywhere (timeshifted TV on any terminal), long-tail VOD contents, multi-device, uniform UI, etc.

From a technological perspective, those solutions propose a new paradigm, using the cloud as infrastructure and taking several advantages of that. Firstly, cloud infrastructure is cheaper, more agile and more efficient, as resources can be dynamically created, scaled or removed. It reduces the service creation time, as using Commercial Off-The-Shelf (COTS) hardware, there is no need for testing and certification for specific hardware. The cloud also leverages the Software as a Service (SaaS) model, and the use of micro-services increases the reusability and efficiency. The cloud helps telcos to focus on their business: the service. Overall, vendors claim for more operational efficiency, faster time to market, and increasing of agility and elasticity.

Examples of vendors well positioned to provide telcos with the technology above: Ericsson with Video Storage and Processing Platform (VSPP) and Cisco with Infinite Video Platform (IVP).

OTT content providers: the Netflix case study

There are several OTT content providers in this exponentially growing market. This section focuses on how the best provider of the class works: Netflix.

Netflix is a stunning case of success and the prominent leader of OTT multimedia content delivery. Today, Netflix is present in more than 190 countries (the biggest exception is China) and has over 100 million customers worldwide, around half of which in the USA, delivering millions of hours of video daily. In 2016, Netflix had revenues of USD 8.8 billion with a profit of USD 186 million.

Netflix provides flat-rate plans to its customers (€7.99, €9.99 and €11.99) and all customers have free access to all contents (SVOD). Multiple devices can be used to access contents, from STB, smart TV, PC, tablets, phones, to gaming consoles or sticks. Associated with VOD contents, Netflix provides other capabilities like search, offline view, ratings, reviews, recommendations, favourites, etc. In 2013, Netflix became a content producer, creating very successful exclusive contents.

Technology-wise, Netflix relies on two different technologies. The first is the Amazon Web Services (AWS) technology, supporting the presentation layer (UI), the Control Plane (CP) and the Full Content Library. The second is an in-house developed system called Netflix Open Connect, supporting content delivery (streaming) through Content Delivery Networks (CDN).

AWS makes use of the Elastic Compute Cloud (EC2), the compute part of the Amazon's offer. It is used to support the servers of the UI and CP, allowing the management of the Virtual Machines (VM) (instantiation, scaling, etc.). It controls the geographical location of instances and implements (anti-)affinity policies. The Amazon Simple Storage Service (S3), comprises the storage part, and it is used to store the full content library, by taking advantage of a Distributed File System (note: Netflix has developed the s3mper software to fix some S3 consistency problems). The Amazon's Service is spread across 16 regions worldwide and 44 availability zones (for affinity purposes).

Netflix Open Connect is a proprietary CDN system (like Youtube or Google have), based on specialized hardware made by Netflix: the Open Connect Appliances (OCA) – see **Figure 1**. Netflix decided for a proprietary solution for several reasons: (1) Netflix represents today a large amount of traffic for Internet Service Providers (ISP), so it is important to have a close relationship with them; (2) Netflix would be too big for Akamai (at the beginning Netflix used Akamai CDN, but then moved to Open connect); and, (3) Netflix claims that OCA are single-purpose and extremely efficient for its operation.

FIGURE 1 – Netflix OCA devices

The OCA hardware has several rack configurations. Those are mixed servers (compute + storage), with 2/4 10Gbps in a Link Aggregation Group (LAG), 14-280 TB storage, and are able to support around 10-20K simultaneous streams. OCA are powered by a FreeBSD system, using NGINX for load balancing in addition to HTTP service and BIRD for routing protocol implementation, namely, for Border Gateway Protocol (BGP).

OCA can be deployed in two different manners: embedded and Settlement-Free Interconnection (SFI) with a Private Network Interconnection (PNI) possibility. In the embedded case, the hardware is shipped to the ISP and installed there, doing BGP-peering in the telco premises. Netflix provides the OCA at no cost and helps with the configurations. The ISP provides space, power, cooling and infrastructure maintenance. In the SFI case, the OCA are deployed in Internet eXchanges (IX), where they can BGP-peer with local ISP there, while in the PNI case, OCA are deployed somewhere else and interconnected via a private link (PNI). The embedded case has advantages both for the ISP and Netflix, minimizing the Internet traffic, while improving the quality experienced by customers, respectively.

Netflix uses different Autonomous System Numbers (ASN) for BGP-peering, the ASN#40027 for embedded scenarios and the ASN#2906 for SFI/PNI scenarios. ISP announce the prefixes of the customers they want to be served by the OCA. This way, OCA know what customers they can serve and pass this information to the control plane. When a particular customer requests contents, this information will be used to select a particular OCA.

Netflix does the pre-positioning of the most popular contents (up to 40% storage capacity) during off-peak hours (fill window). This push strategy allows ISP to save bandwidth at peak-hours (delivery window), smoothing the Internet traffic profile. Fill windows are usually 12-hour long and can be shifted -+2 hours as desired by the ISP. OCA are simply content delivery boxes. All other aspects, like subscribers, Digital Rights Management (DRM), etc., are managed at the AWS.

Figure 2 depicts a basic flow diagram with the Netflix combined operation between the AWS (presentation/control plane) and the Open Connect (caching): (1) OCA periodically (5 min.) report available contents and routability information; (2) a customer presses the "Play" button; (3) AWS authenticates the customer and decides the content to send; (4) AWS selects an OCA to deliver the content based on availability/routability and generates the URL; (5) the customer player uses this URL to retrieve and play the content in the device.

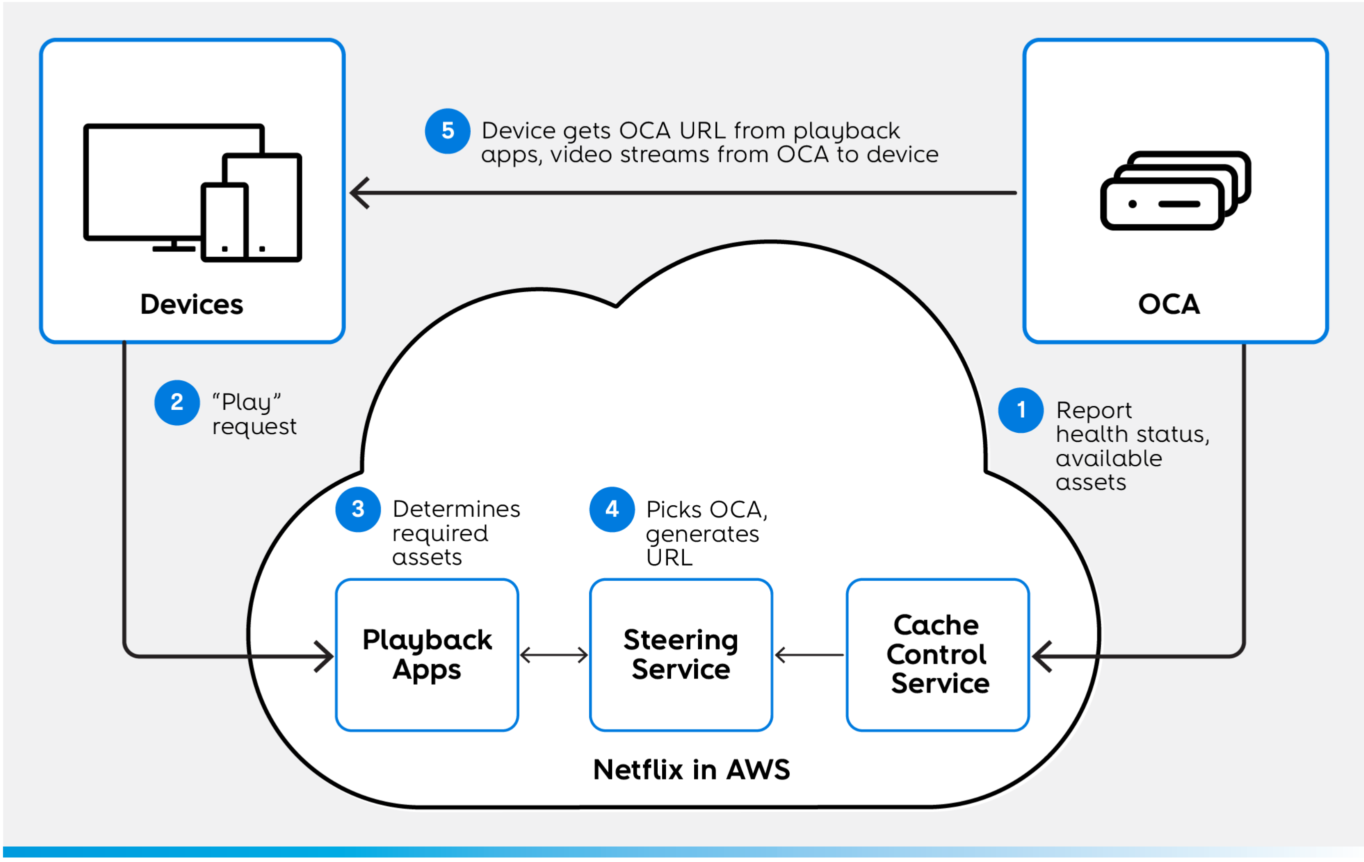

FIGURE 2 – Netflix delivery flow diagram

Proposed strategy

This section describes a proposed strategy from Altice Labs for the Altice Group, considering the different planes: control plane and data plane in two- and five-year timeframes.

Overview

The TV/multimedia of the future will evolve towards a multi-targeting paradigm. Solutions will be: (a) multi-device, supporting different devices and screens; (b) multi-DRM, supporting multiple DRM solutions for different platforms (e.g. Android, iOS); (c) multi-network, using a unified solution to deliver contents to multiple network types (e.g. mobile, Wi-Fi); and also (d) multi-operator, capable of supporting multiple operations on top of the same solution, an important asset for a telco group.

The multi-operator ability relies on the cloud technology, aiming to abstract resources and its location. It allows the service composition (chaining) by using distributed functions around different geographical locations in a simple and powerful way. The cloud principles also support the agility to run different small functions (micro-services) and scale them to adapt the resources to the load. The orchestration of the entire environment with all those functions, resources and location is what we call **software-defined TV** (see **Figure 3**).

Control plane

The CP includes a large set of features: DRM enveloping, stream control, recording management, recommendations, metadata management, etc. It is also responsible for managing subscribers, subscriptions, offers, reporting, charging, and analytics, among others.

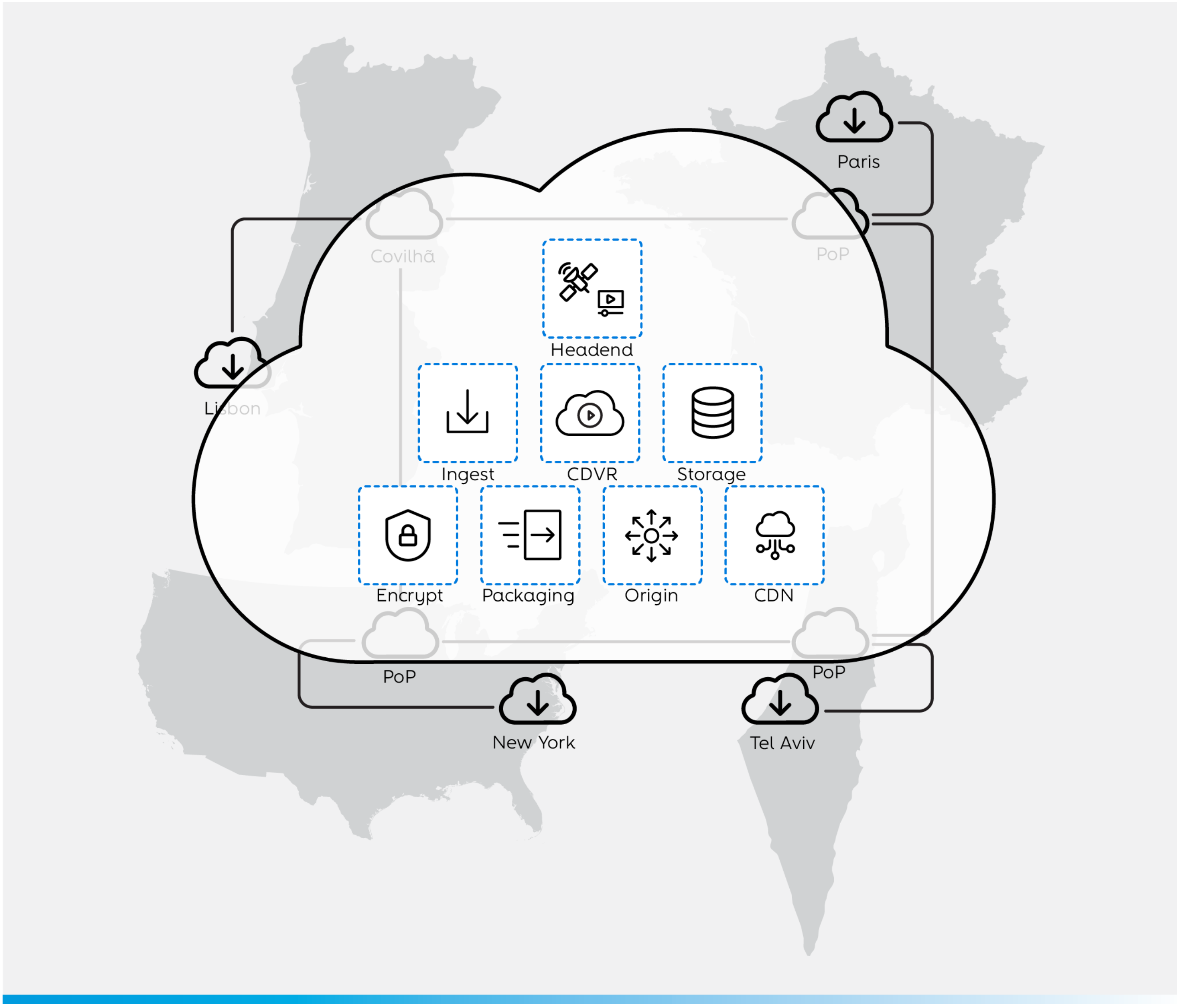

FIGURE 3 – Software-defined TV concept

Today

Today, CP features are highly dependent on the network, the devices and the Media Plane (MP), leading telcos to get locked-in to vendors. Each telco has a different set of systems and uses API to extend them with additional custom logic for its particular operation. This creates a high diversity of telcos' ecosystems, making it difficult for multi-operator groups like Altice to benefit from synergies and take advantage of scale.

Two-year timeframe

In a two-year timeframe, the Altice Group should move towards the control API unification, decoupling and isolating them from internal systems. That means not using the vendor API directly (e.g. mediaroom), rather creating a wrapper around them to perform the desired isolation and remove the dependency. In this sense, all Altice operations should agree on a common API (see **Figure 4**): the **Control-Plane Management Interface** (CPMI). By sharing API, reusability of software pieces will become a reality and synergies will rapidly start to emerge.

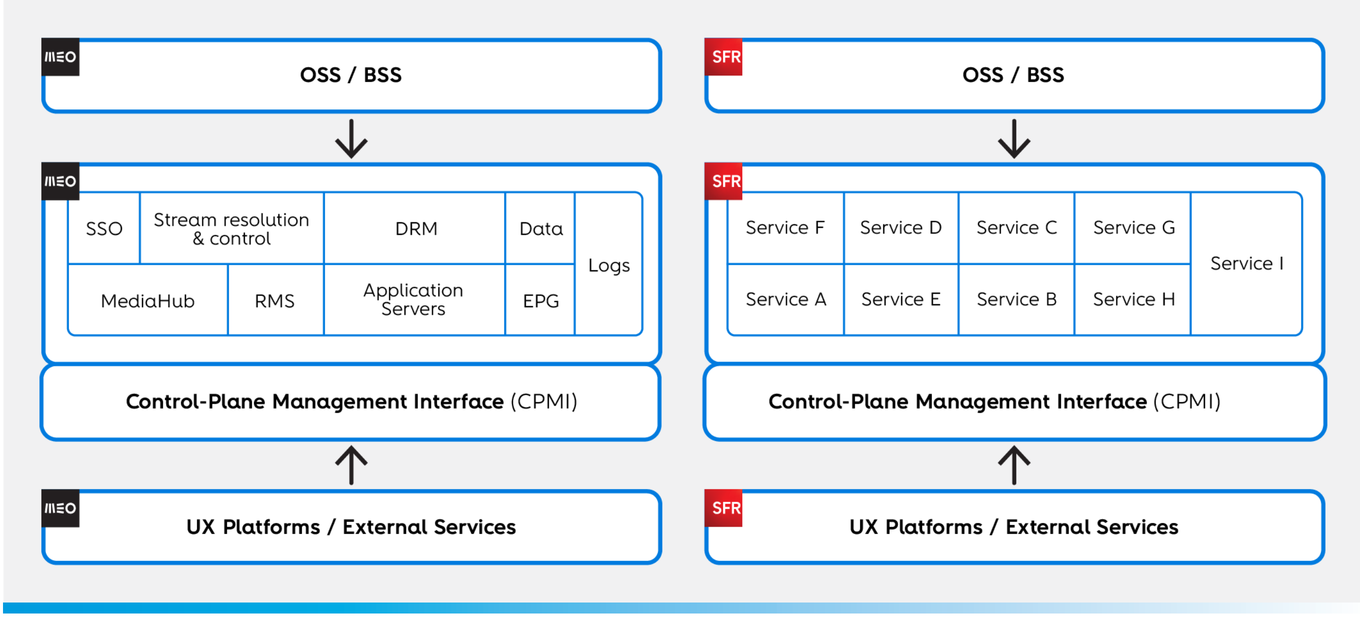

FIGURE 4 – Proposed strategy: Control Plane – two-year timeframe

Five-year timeframe

In a five-year timeframe, the Altice Group should start using the unified API, extending them in order to support multi-operator environments. Gradually, all applications and systems must start using this new API, migrating applications from the existing API in the different operators to the unified API.

Having a common CPMI, Altice can have a global

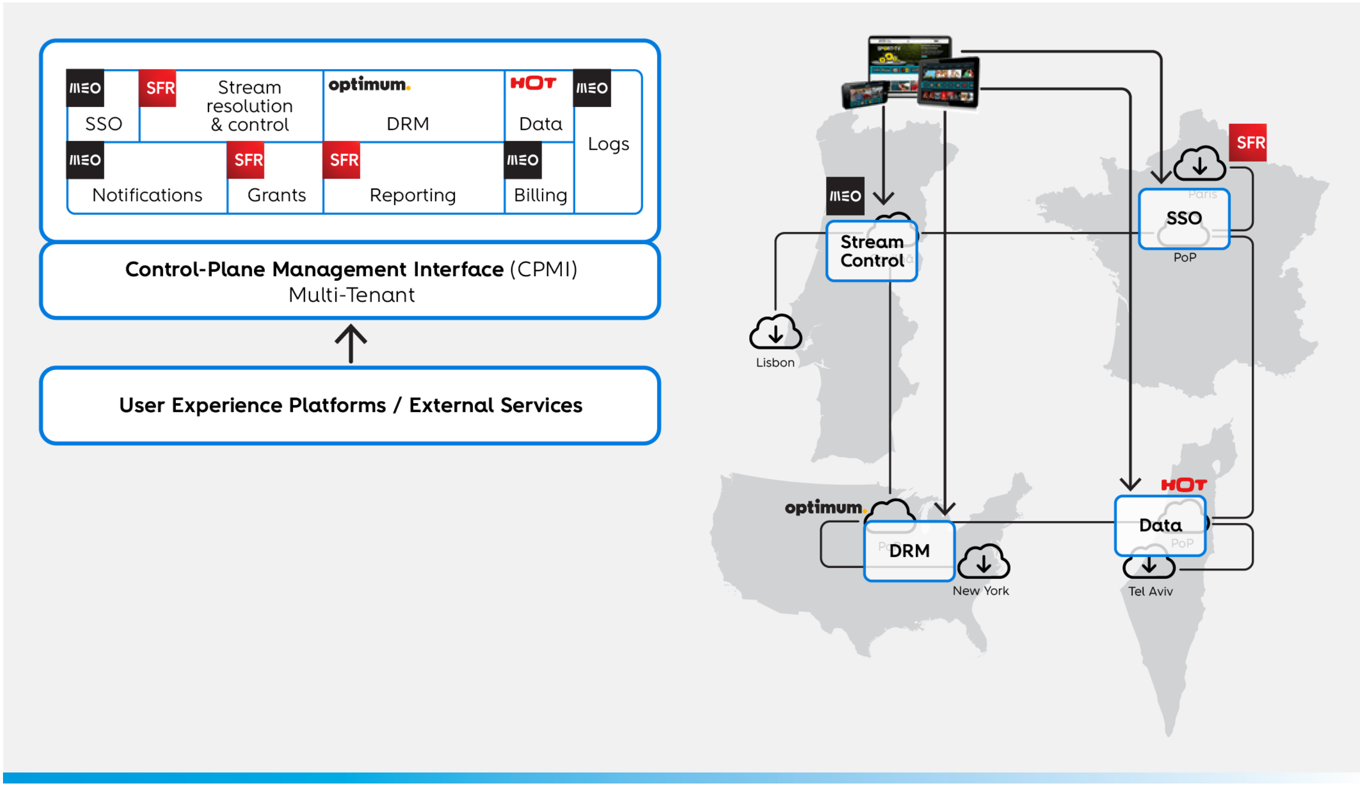

FIGURE 5 – Proposed strategy: Control Plane – five-year timeframe

view of the multiple operations, deploying different services in certain locations to serve multiple operators. For example, a Single-Sign-On (SSO) function can be deployed in location A (e.g. centralized authentication), and all Altice operators perform authentication at this point. The same can happen with DRM or other functions in locations A, B or C. The **Software-Defined TV** model is in charge of abstracting the functions location to the operators, acting as if they were together in the usual manner. **Figure 5** depicts this model.

Media plane

The MP includes a large set of functions (sequenced to acquire, prepare and deliver contents to customers): headend, ingest, storage, DRM, packaging, origin and CDN.

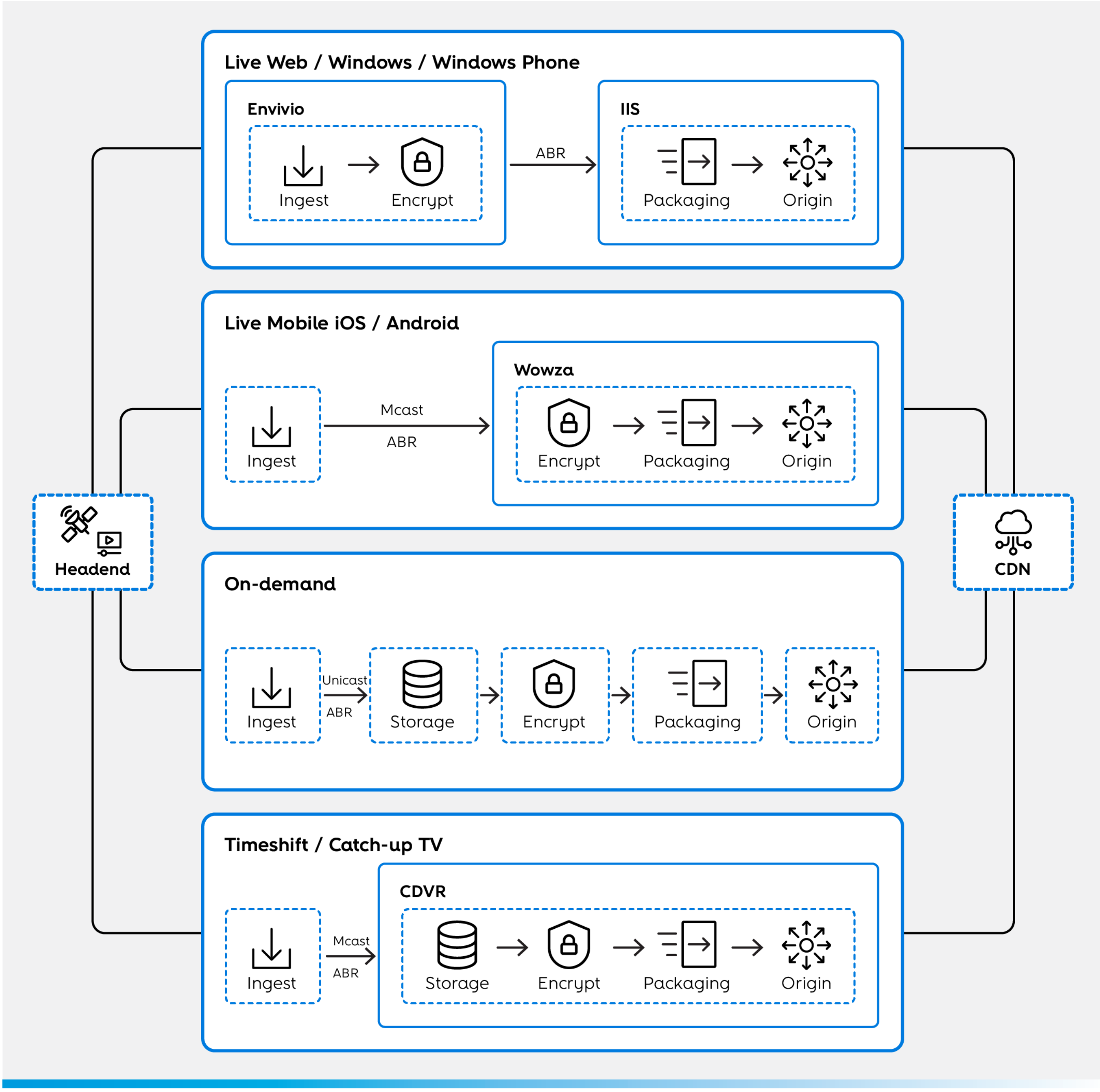

FIGURE 6 – Proposed strategy: Media Plane – today

Today

Today, telcos use multiple monolithic vendor solutions which comprise a mix of functions. The same contents are many times provided by separated systems (mobile, VOD, Android, iOS), leading to vertical silos, where the isolation of functions is difficult. This prevents the reuse of functions, making an inefficient use of resources, licensing, etc. **Figure 6** depicts the example of a typical operator ecosystem, where horizontal chains represent the functional silos used to deliver contents (headend to CDN) for different network/services/devices.

Two-year timeframe

In a two-year timeframe, the Altice Group should segregate and standardize functions, in order to easy reutilization of different services, for various networks and devices. To allow future function reutilization, it must be agreed on a common MP API among operators, the **Media-Plane Management Interface** (MPMI). As a result, the media plane ecosystem of the **Figure 6** could be simplified to the example depicted in **Figure 7**.

Five-year timeframe

In a five-year timeframe, the Altice Group should start using the standard functions, as building blocks, to create TV/multimedia services. Using these functional pieces, a manager can build the desired service, by linking different functions (chain) that can be abstracted and deployed in different locations of the Altice Group. The **Software-Defined TV** model is in charge of abstracting functions location to the operators, acting as if they were together. **Figure 8** depicts this model.

Live multicast vs unicast

This section describes the results obtained in a study regarding the comparison between the delivery of live contents either using traditional IP multicast or unicast (OTT like approach).

Motivation

This chapter attempts to respond to the questions: Is IP multicast still required? Can OTT (unicast) support a telco IPTV delivery? Those are important questions to answer, especially in the current context, where some Altice operations are moving from traditional cable to fibre

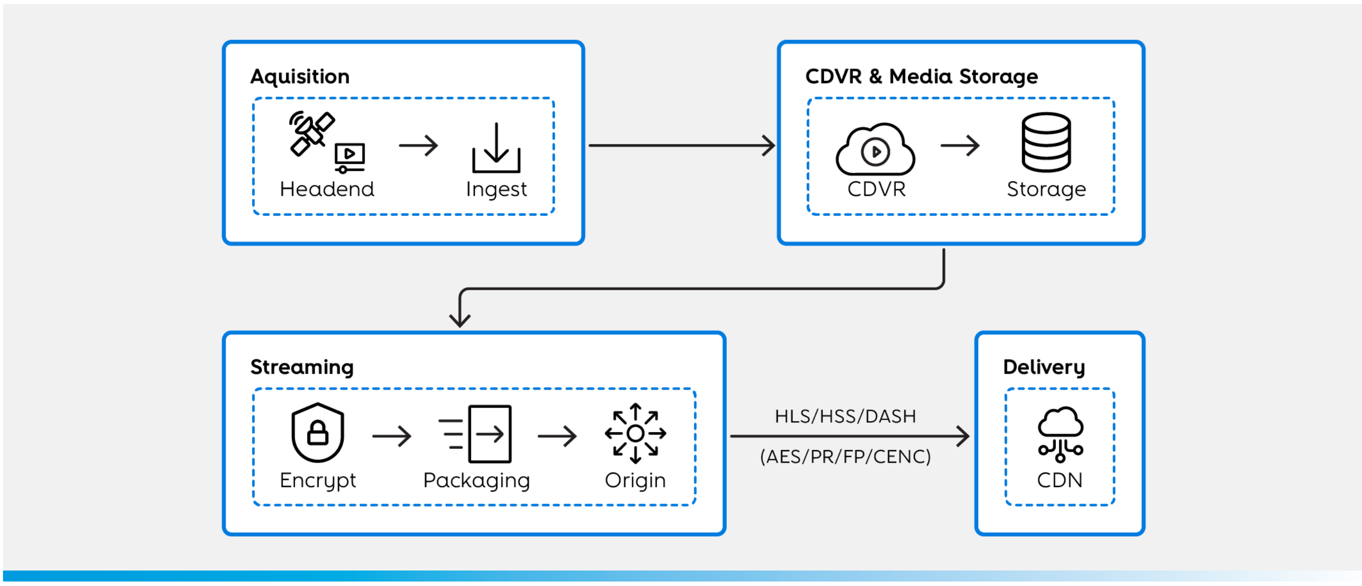

FIGURE 7 – Proposed strategy: Media Plane – two-year timeframe

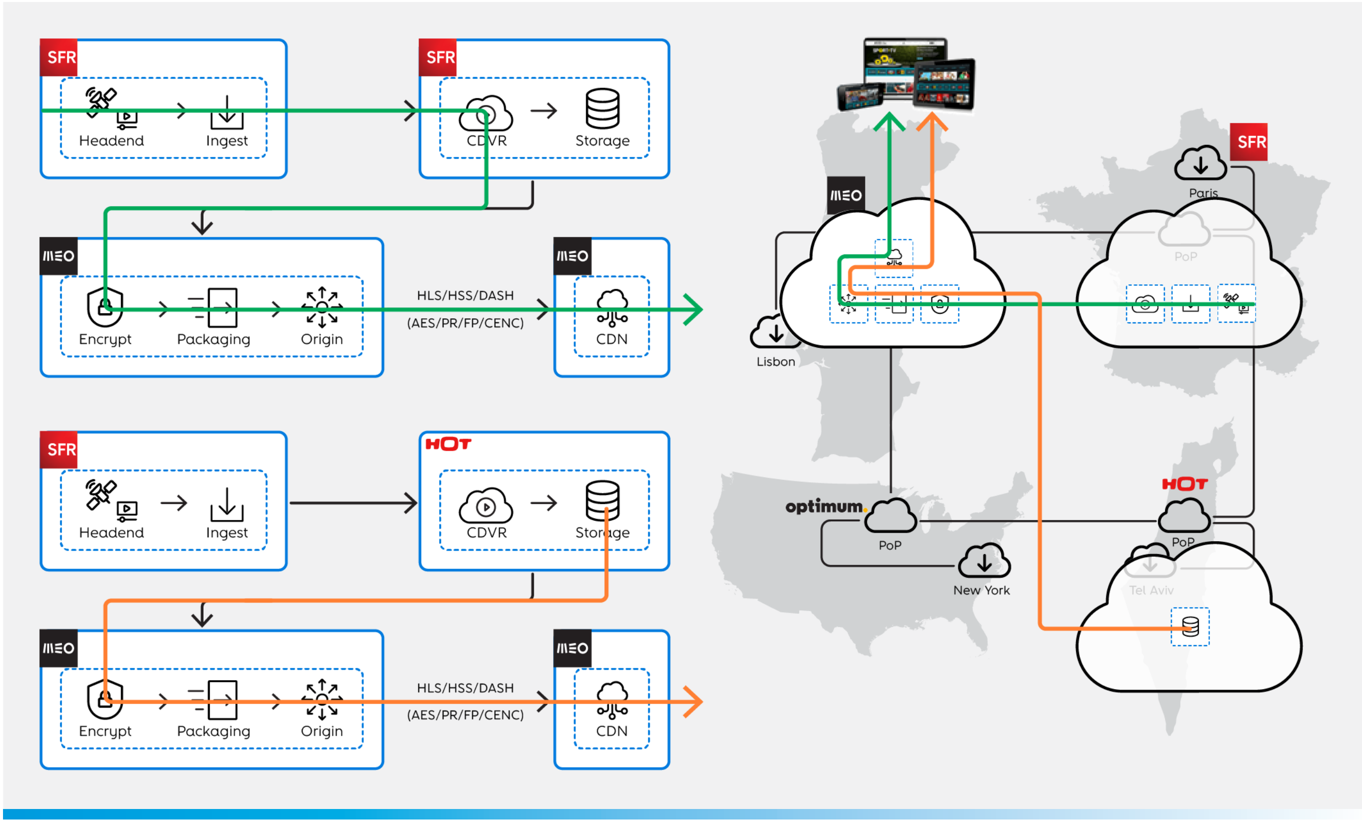

FIGURE 8 – Proposed strategy: Media Plane – five-year timeframe

technologies, and need to decide whether they build a multicast network or use only unicast.

The success of OTT players, like Netflix, delivering contents using OTT technologies, raises doubts on traditional telcos about whether they can do the same (although OTT players mainly deliver VOD content, which is much less challenging than live).

Today, telcos already deliver some contents using unicast. Actually, they use a technology mix: multicast for live and unicast for VOD, timeshift, Fast Channel Change (FCC) and mobile. The unification to unicast would simplify service delivery, reducing overall costs. The gradual reduction of live viewing and the dramatic growing of timeshift and VOD services increases the feeling that multicast is not that important anymore.

Pros and cons

The main multicast advantage is the ability to deliver live contents to millions of customers using a single stream. By definition, multicast creates a delivery tree, forwarding the traffic and forking flows only when required, unlike unicast which requires one flow per customer. This dramatically reduces the amount of traffic crossing the network, smoothing the traffic profile and avoiding peaks at top viewing hours.

However, multicast is not enough to provide all services (e.g. timeshift, VOD, FCC). In the timeshift case, unicast and multicast must be synchronized when the customers push back to the past, increasing the complexity. Furthermore, multicast does not work well in Wi-Fi and requires specific solutions in mobile environments, like Multimedia Broadcast/Multicast Service (MBMS).

The biggest unicast advantage is simplicity. It can be used to provide all services, from live, VOD or timeshift, and can be used in any kind of IP network, from mobile to Wi-Fi or fibre.

The biggest unicast disadvantage is the inefficiency to deliver live contents, which makes mandatory the use of distributed caching systems (CDN). Even though, during peak hours, the traffic will increase dramatically. But the big challenge for unicast, is the support of big events (e.g. the Final FIFA World Cup), when millions of customers change channel almost simultaneously (e.g. at the beginning, half break, etc.), pushing the control plane to the limit.

Reference scenarios

First of all it is important to note that for the sake of simplicity of the simulation, a flat number of clients and TV channels were considered in order to isolate and highlight the potential impact of the traffic mix evolution (the number of clients over multicast and the increase in high quality content streams). However, using the developed simulation tool, all parameters may be changed to reflect the market evolution.

	Portuguese Inspired *						Future USA **					
Parameters	**2017**			**2021**			**2018**			**2021**		
# Clients	1 200 000			1 200 000			1 800 000			1 800 000		
# Set-Top-Boxes	1 600 000			1 600 000			5 400 000			5 400 000		
Peak # Streams	900 000			900 000			1 800 000			1 800 000		
# TV Channels	195			195			500			500		
Channels Bitrate (SD/HD/4K)	2	6	12	2	6	12	2	6	12	2	6	12
Headend Channels Mix (SD/HD/4K)	72%	72%	72%	40%	50%	10%	60%	40%	0%	30%	50%	20%
Channels Bitrate (SD/HD/4K)	80%	72%	72%	55%	40%	5%	70%	30%	0%	25%	60%	15%
Peak # Different TV Channels	161			161			250			250		
Clients Avg. Peak Other IPTV Unicast (Mbps)	0.375			0,750			0,375			0,750		
Clients Avg. Peak Other Internet (Mbps)	0,416			0,832			0,416			0,832		
# Clients per OLT	2 000			2 000			2 000			2 000		
# OLT per Service Router	10			10			10			10		
Computed Parameters												
Headend Multicast Traffic (Mbps)	*610*			*975*			*1 800*			*3 000*		
OLT Uplink Multicast Traffic (Mbps)	*451*			*660*			*800*			*1 475*		
Total # Service Routers	*60*			*60*			*90*			*90*		
Total # OLT	*600*			*600*			*900*			*900*		

* Estimated numbers
** End of 2018 projections

Note: a flat number of clients and TV channels were considered for OTT traffic calculation simplicity.

TABLE 1 – Reference scenario numbers and assumptions

Considering what was said before, this study intends to evaluate how a unicast solution would behave for particular reference scenarios. The purpose is to understand whether it would be possible for the current networks to support an OTT operation, calculating how much the traffic will increase in multiple network sections. The two reference scenarios considered are based on the Portuguese operation (Altice PT) and the USA projections for the end of 2018. Forecasts for a five-year timeframe for each scenario were also considered. The **Table 1** depicts those values and the assumptions considered for the simulation.

Today

Portuguese case inspired

Figure 9 depicts the reference network aggregation.

Clients: Nothing changes since the traffic is basically the same as using multicast. Live IPTV traffic is around 2.1Mbit/s and total (including Internet/VOD/timeshift) around 2.9Mbit/s.

OLT: Significant changes in uplink traffic (downlink nothing changes). Live TV uplink traffic increases from 450Mbit/s to 4.2Gbit/s and the total traffic increases to 5.8Gbit/s. Using 10 Gigabit Ethernet (GbE) interfaces, it would be feasible with current equipment.

Service Routers (SR): Significant changes, in uplink and downlink. Live TV uplink traffic increases from 610Mbit/s to 42Gbit/s and downlink from 4.5Gbit/s to 42Gbit/s. Total traffic raises from 24Gbit/s to 80Gbit/s. Using 100GbE interfaces it is feasible, but not all SR may have this capacity. This would be a good location to deploy CDN. In this case, the downlink traffic would be the same but the uplink traffic will reduce to a similar value as for the multicast case.

Headend: If CDN are not deployed at SR locations, this section of the network would dramatically increase traffic, raising from 610Mbit/s to 2.5Tbit/s. Definitively, this is not possible, meaning that CDN must be deployed at the SR. In this case (on ideal caching), the traffic would reduce to 37Gbit/s, which is reasonable.

Summary: This simulation exercise shows that an OTT (unicast) operation is really possible using current hardware on the network without changes. The CDN deployment is mandatory and SRs are the perfect locations for that.

USA case inspired

Figure 10 depicts the reference network aggregation. The main differences to the Portuguese inspired case are the number of STB per customer and the SD/HD mix.

Clients: Nothing changes, since the traffic is basically the same as using multicast. Live IPTV traffic is around 3.2Mbit/s and total (including Internet/VOD/timeshift) around 4.0Mbit/s.

OLT: Significant changes in uplink traffic (at downlink nothing changes). Live TV uplink traffic increases from 800Mbit/s to 6.4Gbit/s and the total traffic increases to 8.0Gbit/s. Using 10GbE interfaces, it would be too close to the interface limits. Solutions can be the plug-in of additional 10GbE cards or the reduction of the number of customers per OLT.

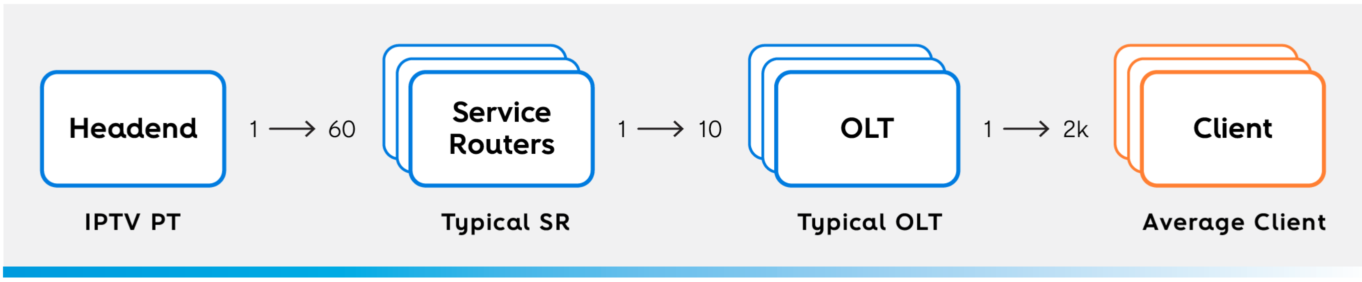

FIGURE 9 – Portuguese inspired network aggregation (estimated numbers)

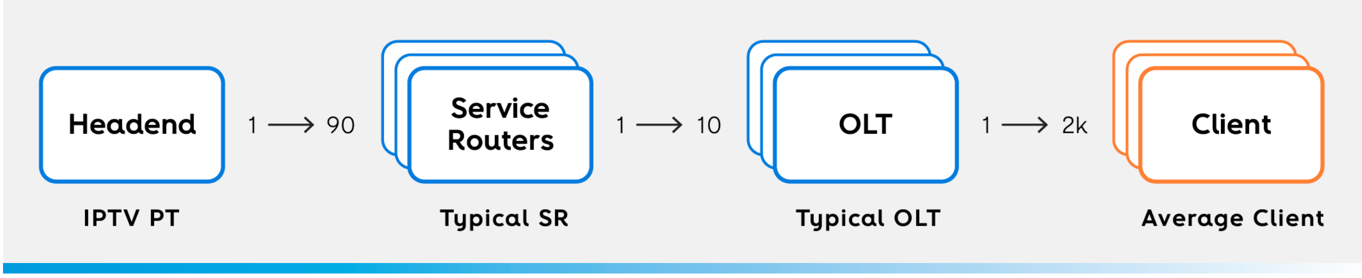

FIGURE 10 – Future USA network aggregation (estimated numbers)

SR: Significant changes, in uplink and downlink. Live TV uplink traffic increases from 1.8Gbit/s to 64Gbit/s and downlink from 8.0Gbit/s to 68Gbit/s. Total traffic raises from 24Gbit/s to 80Gbit/s. Using 100GbE interfaces it would be too close to the interface limits. This is a good location to deploy CDN; in this case, the uplink traffic would reduce to a similar value as for the multicast case.

Headend: If CDN are not deployed at SR locations, the headend would dramatically increase traffic, raising from 1.8Gbit/s in the multicast case to 5.8Tbit/s. Definitively, this is not possible, meaning that CDN must be deployed at SR. In this case (on ideal caching), the traffic would reduce to 162Gbit/s, which is reasonable, but may require additional interfaces.

Summary: This simulation exercise shows that an OTT (unicast) operation is possible, but may require additional interfaces at several points of the network (e.g. OLT, SR, headend). The introduction of CDN is mandatory and the SR are the perfect locations.

Forecasts 2021

After the analysis of the current numbers for the Portuguese and USA inspired scenarios, it is important to understand how this would evolve in a five-year timeframe, where it is expected more Internet traffic, more timeshifted services and higher quality contents (e.g. 4K). Thus, the following assumptions were considered (already shown in the reference scenario in **Table 1**).

Portuguese inspired scenario:

- **Traffic Mix:** Increase from 80% SD / 20% HD / 0% 4K to 55% SD / 40% HD / 5% 4K
- **Internet + Timeshift + VOD:** Increase of 100%

USA inspired scenario:

- **Traffic Mix:** Increase from 70% SD / 30% HD / 0% 4K to 25% SD / 60% HD / 15% 4K
- **Internet + Timeshift + VOD:** Increase of 100%

Portuguese case inspired

Clients: Nothing changes since the traffic is basically the same as using multicast. Total traffic will increase from 2.9Mbit/s in 2017 to 4.7Mbit/s 2021.

OLT: Significant changes in uplink traffic (at downlink nothing changes). Live TV uplink traffic increases from 660Mbit/s to 6.2Gbit/s, and the total traffic (including Internet/VOD/timeshift) increases from 3.8Gbit/s to 9Gbit/s. Using 10GbE interfaces, it would be too close to the limits, requiring additional 10GbE interfaces or the reduction in the number of customers per OLT.

SR: Significant changes, in uplink and downlink. Live TV uplink traffic increases from 975Mbit/s to 61.5Gbit/s and downlink from 6.6Gbit/s to 61.5Gbit/s. Total traffic raises to 93Gbit/s both for uplink/downlink. Using 100GbE interfaces it would be too close the interface limits. This is a good location to deploy CDN; in this case, the downlink traffic would be the same, but the uplink traffic will reduce to a similar value as for the multicast case.

Headend: If CDN are not deployed at SR locations, this section of the network would dramatically increase traffic, raising from 1.8Gbit/s in the multicast case to 3.7Tbit/s. Definitively, this is not possible, meaning that CDN must be deployed at SR. In this case (on ideal caching), the traffic would reduce to 59Gbit/s, which is more reasonable, but anyway may require the addition of interfaces.

Summary: This simulation exercise shows that by 2021, the OTT based operation is possible, but would require additional interfaces at several points of the network (e.g. OLT, SR, headend). The introduction of CDN is mandatory and the SR are the perfect locations.

USA case inspired

Clients: Nothing changes since the traffic is basically the same as using multicast. Total traffic will increase from 4.0Mbit/s in 2017 to 7.5Mbit/s 2021.

OLT: Significant changes in uplink traffic (at downlink nothing changes). Live TV uplink traffic increases from 1.5Gbit/s to 11.8Gbit/s, and the total traffic (including Internet/VOD/timeshift) increases from 4.6Gbit/s to 15Gbit/s. Using one 10GbE interface is not enough, and other interfaces need to be added. The reduction of the number of customers per OLT is also possible, but probably more difficult to do.

SR: Significant changes, in uplink and downlink. Live TV uplink traffic increases from 3Gbit/s to 118Gbit/s and downlink traffic from 15Gbit/s to 118Gbit/s. Total traffic raises to 93Gbit/s both for uplink/downlink. Using 100GbE interface would be too close the interface limits. However, this is a good location to deploy CDN; in this case, the downlink traffic would be the same (118Gbit/s), but the uplink traffic would reduce to a value similar as for the multicast case.

Headend: If CDN are not deployed at SR locations, this section of the network would dramatically increase traffic, raising from 3Gbit/s in the multicast case to 11Tbit/s. Definitively, this is not possible, meaning that caching systems must be deployed at SR. In this case (on ideal caching), the traffic would reduce to 270Gbit/s, which is more reasonable, but anyway may require the addition of interfaces.

Summary: This simulation exercise shows that by 2021, the OTT based operation is possible, but would require additional interfaces at several points of the network (e.g. OLT, SR, headend). The introduction of CDN is mandatory and the SR are the perfect locations.

Final remarks

Overall, these simulations show that the OTT mode of operation is viable, but may require upgrades to the current networks. Although today only minor upgrades are required, in a five-year timeframe the level of upgrades should increase.

In most of the cases, the addition of new interfaces (e.g. 10GbE, 100GbE) is enough. However, in other cases, it may need heavier technology replacement (e.g. 10GbE interfaces by 100GbE). This may force upgrades in the equipment itself (OLT, SR) in order to support such interfaces or to cope with the respective increase in traffic.

The utilization of CDN is mandatory to distribute the content delivery load along the network. Without this, headends will be flooded with Tbit/s of traffic. The best location for the deployment of CDN units is co-located with the SR.

Conclusions

This article presented the results of a study developed by Altice Labs regarding the proposal of a TV/multimedia content delivery strategy for the entire Altice Group, considering two- and five-year timeframes.

The proposed strategy was divided into control and media planes. For both, the focus was put on the utilization of cloud and software-defined technologies in order to leverage the synergies among the different operations from the Altice Group and benefit from scale.

In the control plane, the unification of API and interfaces is the first step to take, allowing the reutilization of control functions by different operators. This unification allows the centralization of services in different locations (e.g. SSO, EPG) to serve all Altice operators in a transparent manner, the so-called Software-Defined TV.

In the media plane, the isolation of standard functions is the priority, making possible the reutilization of functions by multiple services, devices and networks. This allows the Altice Group to use common functions (deployed in certain locations) to serve multiple operations, allowing managers to create flows of function (chains) to also build the service on top of Software-Defined TV.

Finally, a study was conducted to understand whether multicast is still a mandatory enabler for live content distribution, or OTT (unicast) technologies can now replace the traditional model. As a result, the OTT approach seems possible; however, the current network in place may not support the resulting traffic as it is, rather requiring some upgrades, which could go from the simple addition of interfaces to the replacement of equipment. The deployment of CDN is mandatory, ideally co-located with SR.