ANEVIA
INNOVATING THE VIDEO EDGE

INDUSTRY WHITEPAPER

« INs & OUTs of CLOUD DVR »

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Contents

EXECUTIVE SUMMARY

As illustrated by the first deployments, Cloud DVR technology is ready and television viewers are finding this new service very appealing. Indeed, cloud DVR will free viewers from all existing barriers inherent in traditional TV recording systems by allowing them to record a potentially unlimited number of programs, simultaneously if they wish, and replay them on any device of their choice at any time.

More than 20 Cloud DVR services have already been launched in Europe. First feedback indicates that this is an opportunity for operators to monitor capital expenditure and raise average revenue per user.

These first large scale deployments however occurred in an uncertain legal environment and a rather defensive approach from content owners with respect to this innovation. However, certain countries are leading the way to a brighter future, creating regulations that allow the deployment of cloud DVR services under favorable conditions for all the different stakeholders.

However, the regulatory and business environments are likely to remain uncertain and will evolve slowly over time. Telecom operators willing to deploy cloud DVR solutions in this period will have to choose flexible technical solutions that enable them to adapt to these constraints: typically selecting solutions that allow them to handle the transition from 'private copy' recording strategy to 'shared copy' for instance, or even hybrid solutions able to manage various types of recording strategy simultaneously.

In parallel, future evolutions of a cloud DVR architecture must be considered according the opportunities to resolve current bottlenecks and scalable to support increasing usage of Cloud DVR services overtime. A special attention should also be given to conceive and deploy a future proof solution in a quickly changing technology landscape considering the high level of investment required for a Cloud DVR architecture. For example, the variety of formats to be delivered is large and is changing quickly.

In addition one of the fundamental interests of Cloud DVR is to unify TV services and interfaces across all devices with no discrimination linked to eligibility of access without investing in expensive STB equipment.

Finally a cloud DVR service presents many opportunities for operators to achieve economies of scale, reduce churn and increase their knowledge of the behavior and tastes of their customers. Cloud DVR also opens the way to new forms of monetization such as targeted advertising that could be key to easing their relationships with rights holders in finding sources of revenue to share, also opening an advertising window untapped today.

About the author

Damien Lucas

CTO & co-founder Anevia

Co-founder of Anevia with Tristan Leteurtre, Damien Lucas is an expert in video streaming technologies for fixed and mobile networks. Currently CTO of Anevia, Damien also comes from the VLC Media Player development team and graduated from Ecole Centrale Paris, France

[1] CABLE NATION: Fast-Forward To DVR Insights

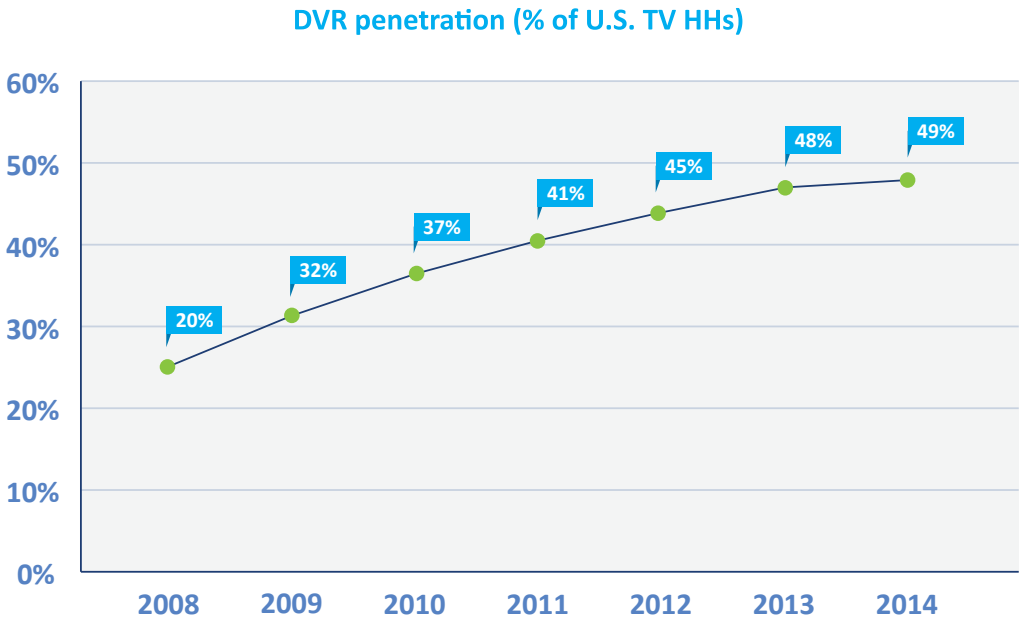
[2] CABLE NATION: Fast-Forward To DVR Insights

[3] ERICSSON Consumer Labs – TV on Media report 2014

2. Introduction to Cloud DVR

2.1. Market trends and DVR

The first commercially successful domestic video recording devices (Philips VCR) was introduced in 1972, followed in 1975 and 1976 respectively by the much more successful Sony Betamax and JVC VHS. Personal video recorders (PVRs) using hard disk drives rather than magnetic tape followed in 1999. Initially, marketing studies predicted a massive penetration in TV households and an explosion in recording usage. By 2015, PVRs have only reached 49%[1] of US TV households. More importantly, penetration has reached a plateau, as illustrated in the schematic below, with a yearly annual growth of less than 7%[2].



When the market initially shifted from analog PVR to digital DVR, the main gain for the end user was the quality of the recorded assets. On an ST- based Cloud DVR deployment, the picture quality is the same as live. The whole challenge of CloudDVR is to keep this picture quality.

Rémi Beaudouin
ATEME, VP Solution & Product Marketing

One one hand, traditional DVR is restricted by the limited disk space in a set top box. On the other hand, TV usage is changing rapidly. Consumers of video content are turning increasingly to alternative video services which allow on-demand access to thousands of programs on platforms such as Netflix. During 2015, the consumption of streamed TV programs by young adults (16-45) is likely to exceed estimated figures for linear TV broadcasts[3].

2.2. Overview of cloud DVR end user benefits

Digital video recording in the cloud (Cloud DVR) offers service-providers the ability to respond to the transformation of TV viewing habits. Unlike traditional PVR, viewers can save and consume TV content on the go. Cloud DVR overcomes the physical constraints of the local hard drive. Instead, it offers a library of video assets stored in the cloud and available on devices such as mobile phones, tablet computers, TV dongles and game consoles.

Cloud DVR offers new possibilities and new user experiences to TV viewers:

- Potentially unlimited recording;
- Storage capacity offered easily adjustable to suit individual customer needs;
- Simultaneous recording of several channels;
- Record a program once and watch it on any device without any constraints;
- Server-side storage allowing redundancy and therefore more security in accessing recorded content on a long-term basis.

For all these advantages to be fully appreciated, shifting from the traditional PVR to a Cloud DVR service must be transparent for the end user. Access to the service and scheduling of recordings must be easy for the viewer to control via a unified TV interface across all devices.

With deploying innovative TV services such as Cloud DVR, operators should be able to develop their end user benefits and consequently to raise their average revenue per user (ARPU) in a competitive landscape. To do so, they need to deploy an efficient and cost-effective solution as a basis for convergent offer between fixed and mobile services and by seeking a faster return of investment on a larger user base.

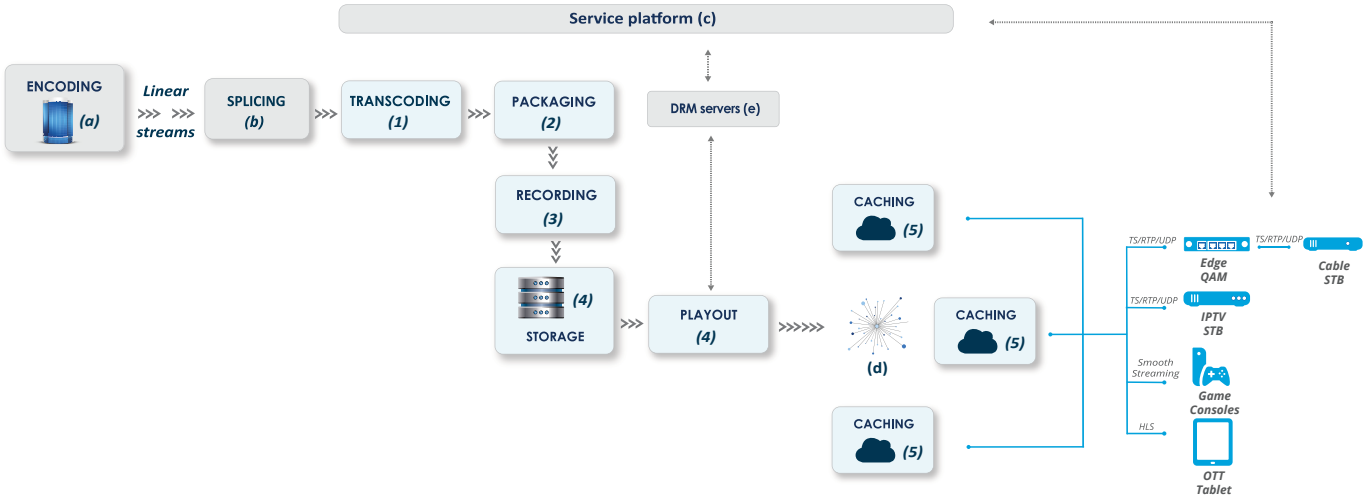
You have to insert the Cloud DVR system into an existing TV content management system while preserving options to evolve or replace that system in support of your business dynamics, such as creating a new inventory of targeted advertising. Mastering the infrastructure as well as video and virtualization is a key success factor.

Lionel Lapras
HP, Head of WW Media & Entertainment

2.3. Basic knowledge of a traditional cloud DVR architecture

Cloud or Network DVR is a technology which has been known for many years but, for many reasons, has not hitherto been deployed. In particular, massive storage technologies were not practical or cost-effective enough. This is no longer the case.

The main objective of this section is to define the technological concepts of a basic Cloud DVR architecture and to present a typical architecture, deployable with existing technologies. This architecture contains a set of functions that have to be fulfilled to deliver a Cloud DVR service, as presented in the following schematic:



Usually, streams arrive already encoded (a) by the provider of the TV channel.

Ad insertion is generally done upstream by a splicing (b) device which replaces the national commercial break with local commercial content.

A continuing challenge for operators who marry linear and on demand content through a cloud DVR offering is ensuring that rights management is applied in a way that is very straightforward for the consumer and preserves technical and commercial latitude for the operator. Using ABR technologies for cloud DVR implementations provides the perfect platform to harmonize rights management.

Verimatrix

The stream then comes to the operator's premises where transcoding is applied to transform the incoming content to the proper format to get delivered to the operator's network (1). In the case of ABR delivery, the transcoding also provides multiple bitrates to adapt to available customer bandwidth.
Usually at the same time, the content is repackaged to fit with the various transport formats required in the market (HLS, Smooth Streaming, DASH for instance for ABR, Transport Stream for IPTV).
All combinations of codec, format and bitrates are then recorded (3) in a large and high performance central data store (4).

Once requested, the content is replayed in the proper format by a playout device (4) which can be an origin server for ABR or a streaming server for IPTV delivery.

The content is delivered to the consumer devices through the operator network or the Internet (d) and is therefore cached (5) in a Content Delivery Network (CDN) to off-load central systems and increase performance.

In addition to this recording and delivery architecture, the Cloud DVR solution as a whole requires a service platform to enable the interaction between the devices and the Cloud DVR architecture. Especially, this service platforms needs to manage Electronic Program Guide (EPG) data, as well as information about the recording (start and stop time, event name). It can also manage user information such as allowed recording quotas.

This service platform also manages DRM license delivery. The encryption can be applied in different places depending on the system architecture. In the more conservative case, the encryption is performed during initial recording. Encrypted content is then decrypted on the user device. It could also be applied at playout but this requires other secure-storage mechanisms.

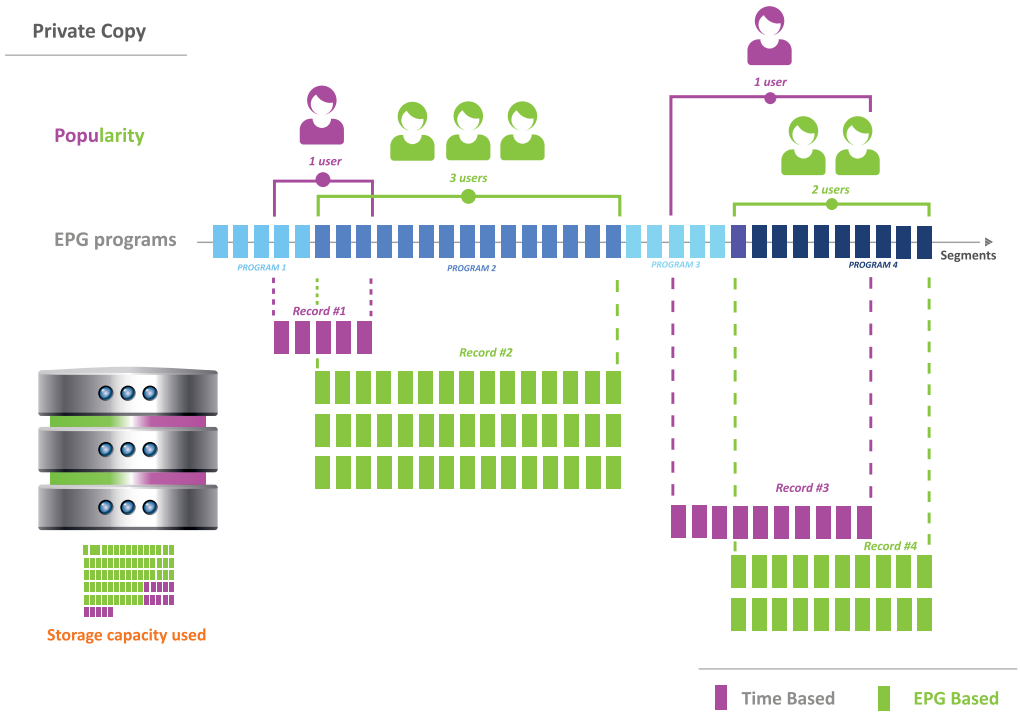
Both the technology underlying Cloud DVR and the Cloud DVR component characteristics themselves have evolved a lot in the past year or two. This creates an opportunity to rework the architecture. The next sections show how this architecture could be evolved to resolve current bottlenecks and enable increased use of Cloud DVR services.

3. Technical issues related to migration of recording on the Cloud

3.1. Three storage approaches: 'private' vs 'shared' vs 'true shared' copy

Technically, two main choices are possible for a Cloud DVR implementation: 'unique copy' or 'shared copy' approach.

In the 'private copy' model, every time a customer records a program, the Cloud DVR system creates a new file that contains this piece of content. For every recording, even if this is the same piece of content recorded by two different users, a separate file is created and stored.

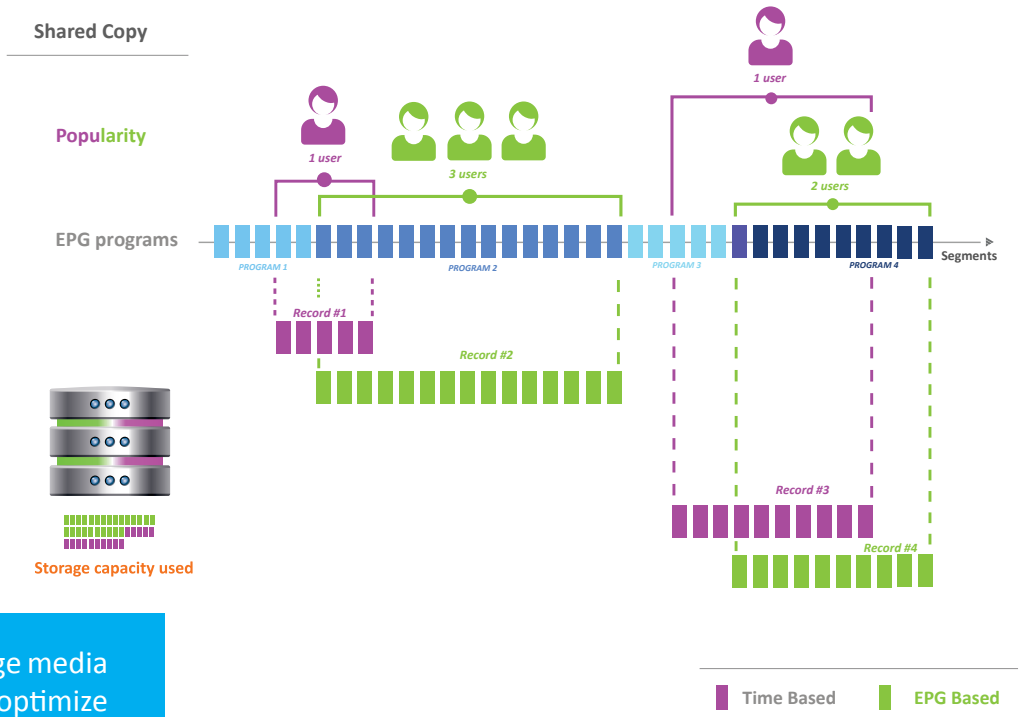


In the 'Shared copy' model, if the same content is recorded by different users, a single copy of this content is stored. In this case, there is a huge optimization of storage space as the content is stored once for all.

This 'shared copy' approach works well in the case of EPG based recording where the start and end time are the same for all customers recording the same show. Most solutions only implement a shared copy in the specific and limited case of EPG based recording.

Most operators face challenges when it comes to evolving from simple video on demand workflows to multi-screen, OTT and Cloud DVR services: the Origin storage capability to scale, both in terms of performance and capacity, becomes a critical success factor. From our experience, Cloud DVR storage architecture should be designed with simple yet powerful management and scalability as mandatory features.

Thore Rabe
EMC, VP EMEA – Isilon Division

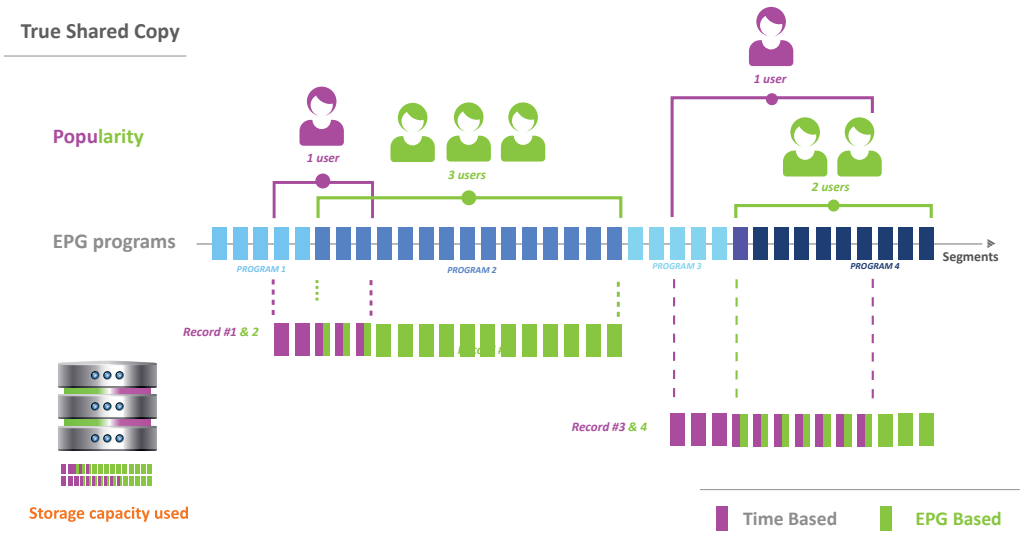


The dropping cost of storage media means that you can optimize your investment by considering how much capacity is needed for the service year one and then purchasing additional storage capacity and bandwidth at regular intervals as the delivery service grows. A petabyte in two years will cost significantly less than a petabyte today.

Jason Danielson
Netapp, Media and Entertainment
Solutions Product and Solution Marketing

But real life is not so simple. First of all, EPG data can often be inaccurate, This creates corrupted files missing the beginning or the end of the program. Additionally, customers want to use the same features with Cloud DVR as they do with a traditional PVR, setting 'time-based' recordings and immediate recording. In these two cases, the start and end time of a recording vary for each user. Even for the same show, the user can change the start and end time, making the recording slightly different from one user to another. In this scenario, for many solution providers, as soon as the recordings are not overlapping, their solution falls back into a 'private copy' mode and will duplicate the content for each user.

This is where the 'True shared copy' approach is particularly relevant. This strategy allows content to be stored once for multiple recordings, even if they are not fully overlapping. As illustrated below, the 'true shared copy' is the most efficient recording strategy in terms of storage capacity. It also allows all highly appreciated features of Cloud DVR, especially time based and immediate recordings, to be preserved:

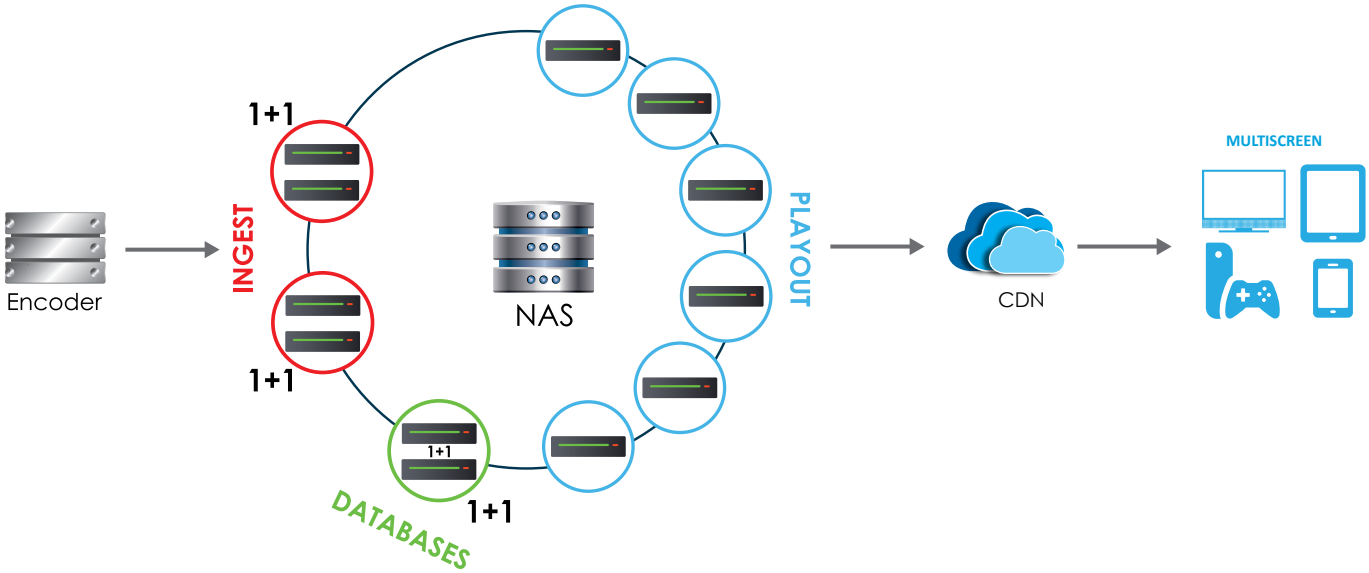


But the recording strategy (private vs shared) is not the only choice impacting the architecture.

3.2. Embedded Distributed storage : an alternative to the classic NAS

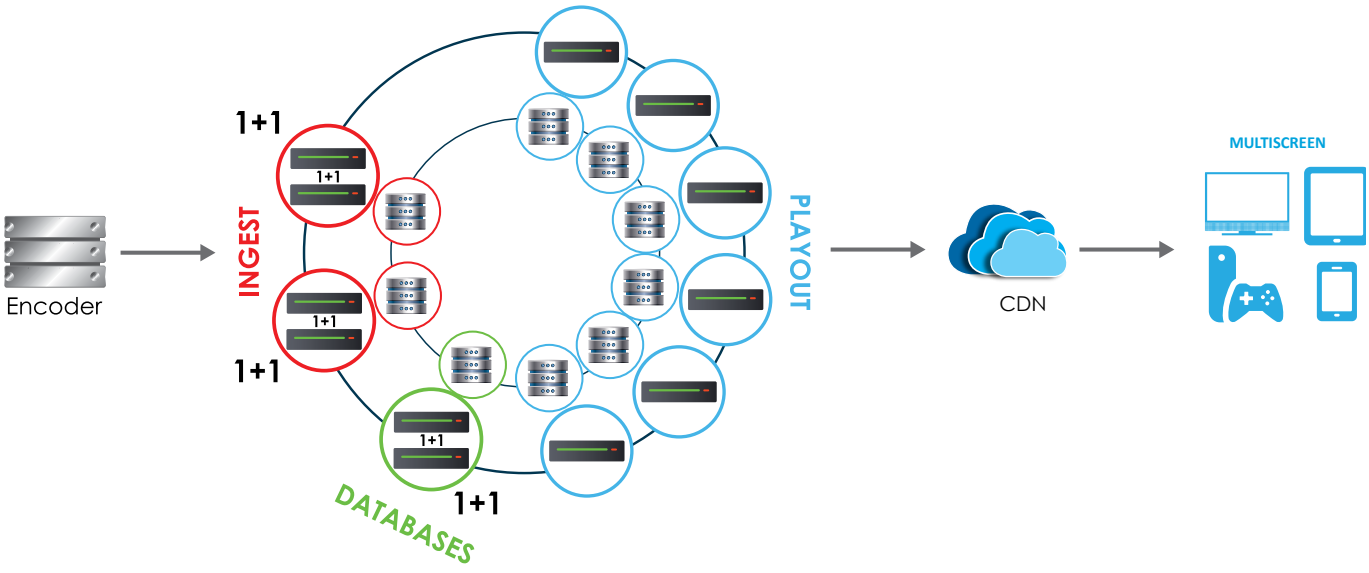
The classical NAS architecture (see figure 1) has some limitations in terms of scalabity: in order to get more capacity, the operator should deploy more playout nodes and more storage nodes (in the NAS) as well as increase the network connectivity between playout nodes and NAS nodes.

Figure 1



An alternative architecture is to use an embeded distributed storage (see figure 2) in order to optimize the scalability.

Figure 2

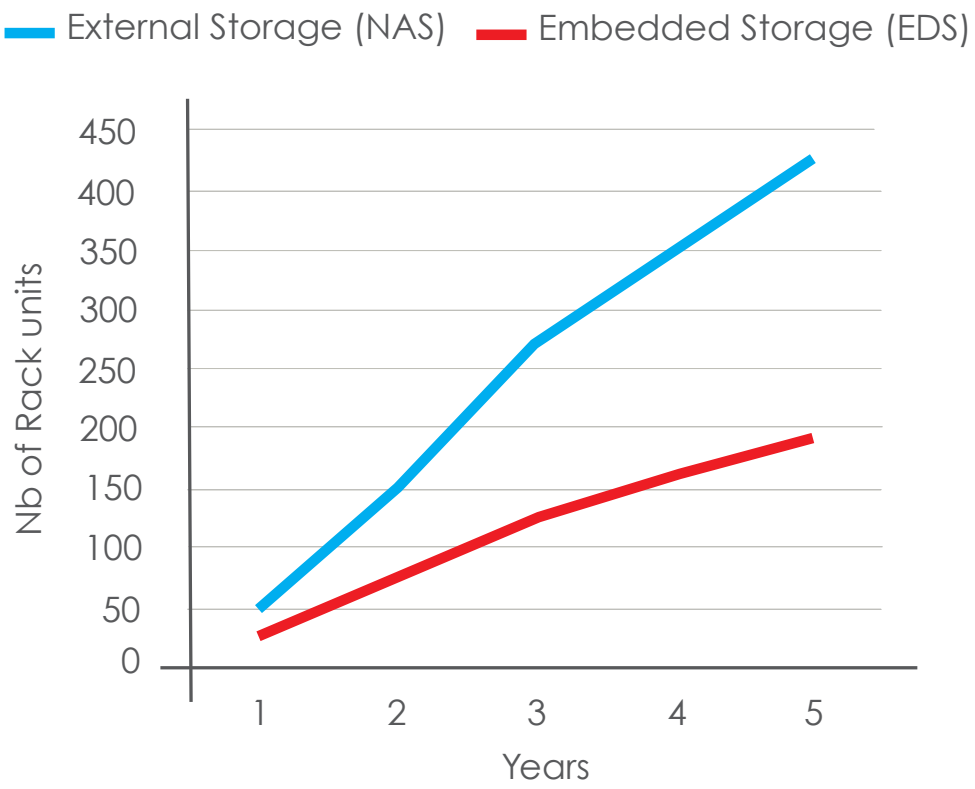


In this embeded distribution storage architecture, the storage costs is reduced by using the storage capacity builtin in each playout node. In this setup a virtual NAS is created by writing and reading data across the different playout nodes, just as a RAID array is created by writing and reading data across different disks.

Benchmark data from Anevia customers give below the space used by servers required for a NAS- and an EDS-based deployment for different types of media and telecom customers.

MEDIA					
Rack-unit	Year 1	Year 2	Year 3	Year 4	Year 5
External storage (NAS)	47	150	270	349	426
Embedded Storage (EDS)	24	74	126	162	192
Ratio NAS/EDS - RU	2	2	2	2	2

Example of a deployment for a media



Rack-unit	Year 1	Year 2	Year 3	Year 4	Year 5
TIER-1					
External storage (NAS)	80	106	123	136	147
External storage (NAS)	80	106	123	136	147
TIER-2					
External storage (NAS)	63	74	80	90	96
Embedded Storage (EDS)	32	34	36	40	46
TIER-2					
External storage (NAS)	14	26	50	63	75
Embedded Storage (EDS)	10	18	28	38	46

The ratio of 2 between NAS-based solution and EDS regarding the number of servers and the number of racks is explained by the use of internal hard disk drives of the servers seen as a global filesystem allows those servers to provide both computing and storage ressources from a single system. At the opposite, NAS requires dedicated servers for storage, and additional servers are necessary for ingesting, packaging and delivering the contents to the CDN/end-users.

3.3. Current technical issues and their impact on the architecture

Considering the high level of investment required to deploy a Cloud DVR architecture, one of the main concerns is to deploy a future proof solution in a quickly changing technology landscape. The variety of formats to be delivered is large and is changing quickly. Adding a DRM format on top of it brings an increasing complexity.

For instance, delivering a program in IPTV and ABR format with, let us say 5 profiles, 2 DRMs and 3 formats (HLS, Smooth Streaming, HDS), could lead to a combination of 20 to 30 different files. In addition to being impractical, it is an absolute waste of storage to record all these variants. Let us imagine now what will happen when another format emerges. Let us say the operator wants to introduce DASH on top of its existing catalog, it will have to process all the recorded content to get it compatible to DASH. This will cost processing time and extra storage, not counting project management costs.

Another option could be to record only one version of the content, in a mezzanine format and get it repackaged to the requested format at delivery time. As encryption formats vary depending on delivery formats, encryption also has to be performed in real time.

Cloud DVR services can now be deployed from Cloud platforms following the evolution of local regulations. Transitioning from STB to the Cloud can be fast and easy, especially with an end-to-end solution that has software embedded in the device while the application logic and storage are integrated within the platform itself.

Jean-François Galtier
Netgem, Deputy General Manager

Repackaging and encryption are operations that can be performed in real time with current server hardware capacity so there is no technical obstacle but this implies a new architecture. Repackaging has to be performed after storage. More conveniently, it could be combined with the playout in an origin server providing real-time repacking, encryption and playout.

Moving the repackaging downstream of the storage will reduce the storage burden by at least 2 to 3 times depending on the number of formats and DRM combinations. In addition, it will reduce the storage performance (throughput) requirements by an equal amount.

Thus, from the network perspective, all the stream variants will still have to be carried across up to the edge. If the same content is requested 10 times, it will have to be played 10 times by the server.

The first optimization in this scenario would be to deploy a CDN. A CDN comprises layered caching nodes. In this case, the first layer could be inside or close to the playout itself. This first layer of cache will offload the storage from all popular content requests, which is usually 80% of the total consumption, and will reduce the throughput requirements of the central storage. It will not change the amount of storage required.

All the content will still go through the network in all possible format and DRM variations. The network load remains at maximum.Without any other optimization, the network will have to carry all the traffic serving end users. Deploying caches at the edge will solve this issue. When the same content (in the same format and DRM) is required by a user connected to the same node, it will be served by the edge cache. Content not already cached will be served by the previous node and will be cached at the first time it is served. Deploying caches at the edge will offload the long distance network. All format and DRM variants of the content will still need to be carried along the network ,even if this is only to feed the edge cache once for all. Moving the repackaging to the edge cache will reduce the network load even more as only the mezzanine version of the content will be moved to the edge. In this later case, the encryption will have to be performed at edge level for the same reason as previously explained[4].

3.4. Future architecture model

Some important elements have to be considered when designing an architecture with all these optimizations:

- First of all, the content has to remain secured all along the way. Repackaging can only be performed on an unencrypted item but content owners will not permit it to travel up to the repackager without encryption,

4. Anevia whitepaper «Edge-packaging will be key for guaranteed live OTT distribution with CDNs»

especially if the repackager is in the edge. In this case, the content will have to be encrypted before the packager with a private key, using the Advanced Encryption Standard (AES) typically, decrypted in repackager and re-encrypted with the target encryption scheme and key to get delivered to the end user.

- Optimization of the CDN is a tradeoff between cache storage cost and network bandwidth cost. Moore's law predicts that storage capacity doubles every 12 months at the same cost. Our estimate over last 15 year period is that network bandwidth increases by 20 to 30% every year. It will become more and more cost effective to store content compared to delivering it over long distance networks.

- Optimization of the CDN will also need to take into account the highly interactive nature of the Cloud DVR traffic. Especially, features like instant pause, play while recording and start-over will imply that the CDN and all its cache levels are able to deliver the content without adding too much delay. This consideration could favour moving the recording up to the edge cache for popular content, especially for start-over. More importantly, this implies a specific characteristic: the CDN cannot operate at file level. If an event is recorded as a whole file and not as small chunks, the CDN will not be able to cache it until it is wholly recorded. Managing all the recordings as chunks will ease the deployment of previously listed features and make them automatically compatible with standard CDNs. If the recording and CDN are operating at chunk level instead of file level, it will become even more efficient in terms of caching efficiency (hit ratio).

To make the storage and the delivery of the content at the optimal cost is definitely the game changer in - CloudDVR technology. The use of packaging on the fly enables the most cost-efficient workflow. This is getting possible thanks to the CENC scheme allowing the content to be encrypted just one time and supplied in DASH format using the DRM interoperability.

Noam Eshel
Viaccess Orca, VP Solutions and Engagement Products

All these optimizations will be extremely efficient in the case of shared and true shared copy implementations. In the case of private copy, most of the load will be transferred to the storage. Storage size can still be optimized by packaging after the storage but the CDN will not be able to offload efficiently the storage as different

Cloud computing allows media companies to benefit from the cloud model and be more efficient and more competitive on their respective market segments. Businesses rely on Amazon Web Services to develop new services quickly while keeping their development costs under control and ensuring servers are available at any time without requiring heavy investments.

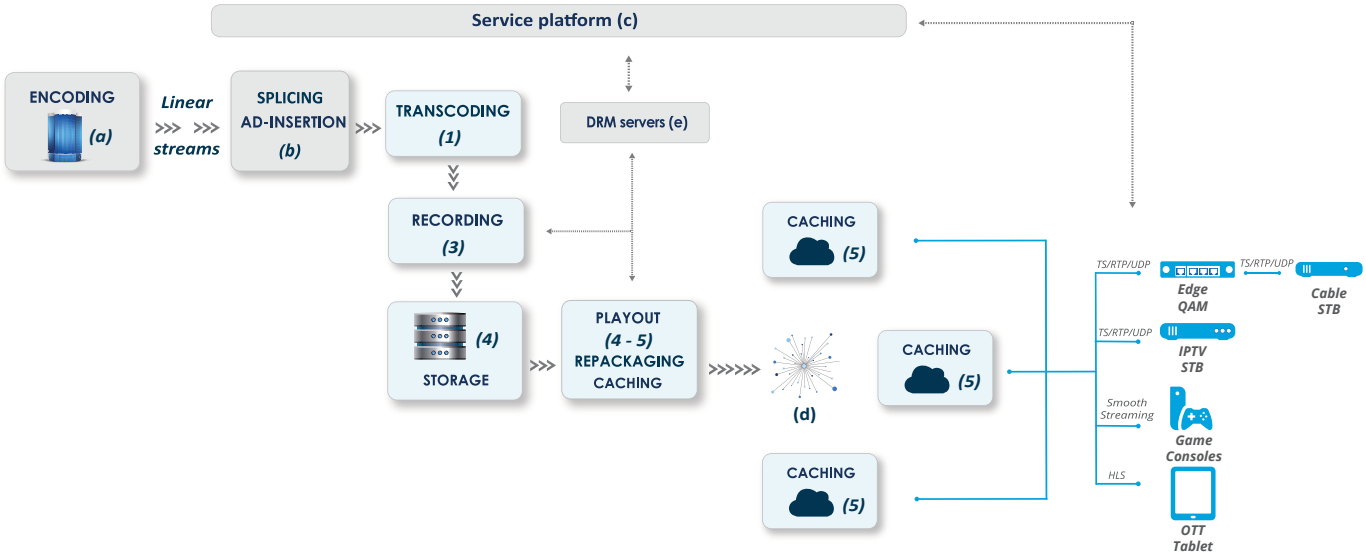
Benoit Lecoeur
Amazon Web Services
Senior Manager Partners and Alliances

files/chunks have to be served for different users. In this case, storage elasticity is even more important than in the shared or true shared copy case: for sizing and for throughput.

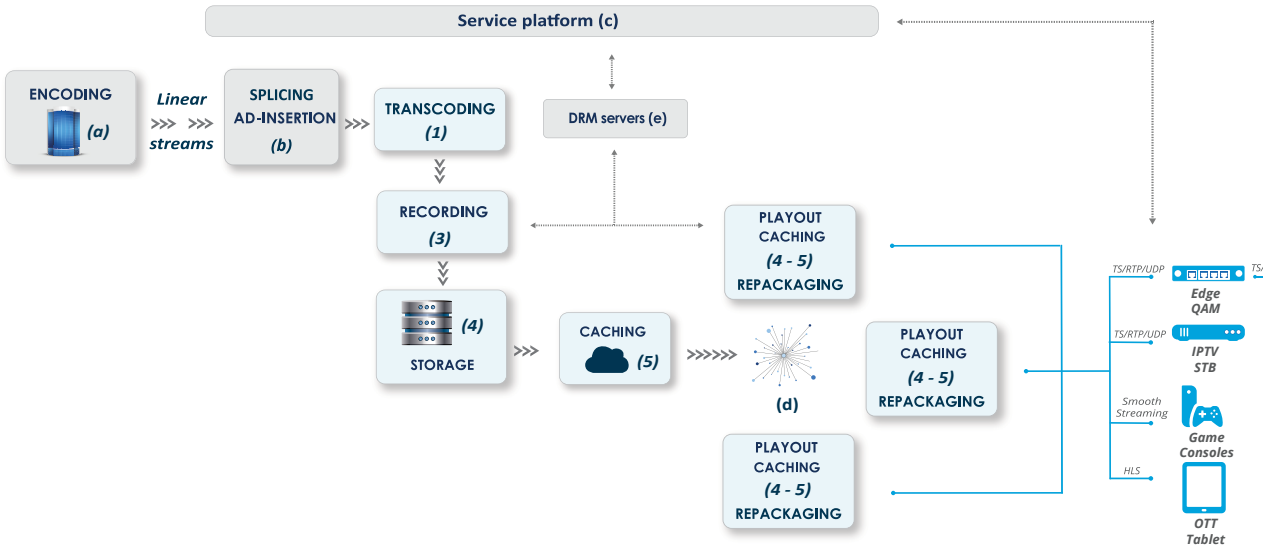
In terms of optimization, operators can also benefit from a hybrid approach between capabilities deployed in the device and in the network. For example, deploying time shifting based on a Cloud DVR approach only can lead to a huge load of traffic because the peak usage of time shifting is very high. This concurrent usage will lead to a very high network and CDN load. In this specific case, it could be very interesting to have an hybrid approach where shifted content is stored in the device RAM. If the user exceeds the allowed RAM size, the application will then fall back to the Cloud DVR to find the content. With a correct tradeoff between RAM size and price, this will reduce very significantly the network/CDN load induced by time shifting and similar features. Doing this is like extending the CDN caching features to the device itself. The following table summarizes the different possible optimizations :

Element	Change	Storage Impact	Network Impact	Other advantages
Repackaging	Move after storage	Reduce size Reduce throughput	None	Easy to add new formats / DRM; no content reprocessing required
Repackaging	Move to the edge	No more than previous	Reduce traffic over WAN	Same
CDN	Cache content close to playout	Reduce throughput	None	
CDN	Cache content close to edge	None if content is cached close to playout Reduce throughput otherwise	Reduce traffic over WAN	Better performance for user (reduced network latency for trick modes)
Storage	Distributed storage	Ability to grow in size and throughput more easily	None	

To implement all the optimizations described above, the architecture becomes:



Pushing further to reduce the network load and benefit from quickly decreasing storage cost, the architecture can be transformed as follows:



4. Cloud DVR challenges legal questions and technical implications

4.1. An uncertain legal framework

Putting video recording capacity into the cloud is not a new concept. Several players in the TV industry began working on this technology immediately after the launch of the first PVRs in the 1990s. But this service encountered many difficulties due to an uncertain legal framework.

Cloud DVR suffered from the interpretation and transposition of copyright laws to a technological innovation, replicating the conflict known as the 'Betamax case': Thirty years ago, Universal City Studios perceived Sony Corporation's Betamax video recorder as a threat and went to the high court to block its use for copyright infringement. In 1984, the Supreme Court of the United States ruled that the making of individual copies of complete television shows for purposes of time shifting does not constitute a copyright infringement but is considered as 'fair use'. This decision set a precedence for the PVR.

This turned to be a huge business opportunity for content owners, allowing tremendous development for the home video entertainment market with video cassette, DVD and Blu-ray sale and rental.

History tends to repeat itself. Immediately after March 2006, when the US Cable Television provider Cablevision announced its intention to deploy a remote storage DVR (RS-DVR) for its subscribers, a consortium of content owners started suing it for copyright infringement. Despite the fact that using a VCR to time-shift had been considered fair use since the Sony Betamax case, content providers considered this was not applicable to its online equivalent. Their argument was based on the fact that transmitting content to users as streams over the internet

constituted a 'public performance'. Consequently, they considered cloud DVR more like a VOD service than a disk-based PVR. Content owners argued that the operator was making a copy of the content to use for public-performances, i.e. distributing it to its customer in differed time, which does require a specific license[5].

Cablevision strove to demonstrate it did not infringe copyright owners' public performance rights. According to Cablevision, its Cloud DVR offer belongs to the sphere of 'private copy' because the service is based on the principle of unique copy. Every recording is the object of a specific and personal copy in the cloud for every user. In that respect, the end-user is responsible for the recording and in this way cloud DVR offers the same functionality as a disk-based PVR.

In 2008, the US Court of Appeals held that the Cablevision RS-DVR does not infringe copyright owners' public performance rights and authorized the service.

Nevertheless this case law did not always apply.

In France, Wizzgo [6], an online PVR platform providing direct cloud recording of live broadcast streams from an EPG, closed only a few months after its launch in May 2008. Lawsuits started only one month after the service began. Like Cablevision, Wizzgo explained that this service has the same functionality as a digital recorder and relies on the private copy technology. But this did not convince the Paris judge who ruled in content owners' favor and confirmed that Wizzgo's service was infringing copyright law. The judge determined that the copyist is the person who is actually performing the copy.

In September 2013, Aereo[7] launched in the US a service allowing users to watch live and recorded TV from over-the-air broadcast television on internet-enabled devices. Aereo was marketing this service as a 'cloud service' over the Internet. In a recent trial, the court ruled that this offer could be considered as a public performance of a copyrighted work and forced Aereo to stop the service in June 2014. The company filed for bankruptcy on November 2014.

As illustrated by Cablevision and Aereo cases in the US, or Wizzgo in France, the world is far from a universal and standard legal approach to 'cloud based' recording. Rulings may still vary from one jurisdiction to another, or from one technical implementation to another.

5. http:// scholarship.law.berkeley.e du/cgi/viewcontent.cgi? article=1775&context=btlj

6. http://www.internationallawoffice.com/newsletters/detail.aspx?g=a08cc455-b5ae-42d4-881d-fa85fc7c3a53

7. Aereo and the Public Performance Right, Cablevision, December 2013

4.2. Some solutions emerge

Switzerland chooses to regulate

These few examples illustrate how uncertain the legal framework can be and could explain why so few cloud DVR services are deployed today. However, Switzerland is paving the way to rule how cloud PVR can be deployed in a regulated approach.

Since 2012, the Swiss regulatory authorities have allowed a service provider to propose a cloud DVR offer in return for a fee paid back to content owners. The

legal framework has empowered the marketing of a Swisscom cloud DVR offer based on a shared-copy approach. However, this agreement is subject to certain limitations: allowed storage capacity and/or retention time of recordings may vary depending on the type of recorded content. Negotiated fees in the agreement vary between CHF 0.80 / US$0.86 (basic) and CH 1.20/$1.29 (premium) per month per 'activated' end-user, depending on recorded content type[8].

This agreement allowed the deployment of two services in Switzerland: Swisscom and Netplus.

> When we launched the service, our target was to offer start-over on a selection of 20 channels. This service was then expanded to replay (24h at first then 7-day). Since May 2013, we have been providing users with a Cloud DVR feature spanning 130 channels.
>
> *Romain Lonfat*
> *Netplus, Head of iTV Group*

Comcast : a graded approach

Despite legal uncertainty, Comcast, the US leading cable operator, launched its own cloud DVR service in April 2014. In order to avoid the drawbacks of a massive deployment, the offer is being introduced gradually deployed and is currently only available in Atlanta, Baltimore, Boston, Chicago, Philadelphia, Washington D.C., San Francisco Bay Area and Houston (as of November 2014). Recording strategy and service architecture are set up to be compliant with Cablevision law case and, especially, private copy.

Other operators may launch their cloud DVR service if they can find a good tradeoff between the obvious benefits of this service and the risk related to regulation and content-owners' current reluctance. The growing consumer appetite for these services and for multiscreen, as well as the opportunity to cut deals with content owners to add value and share it around cloud DVR, could bring the missing momentum.

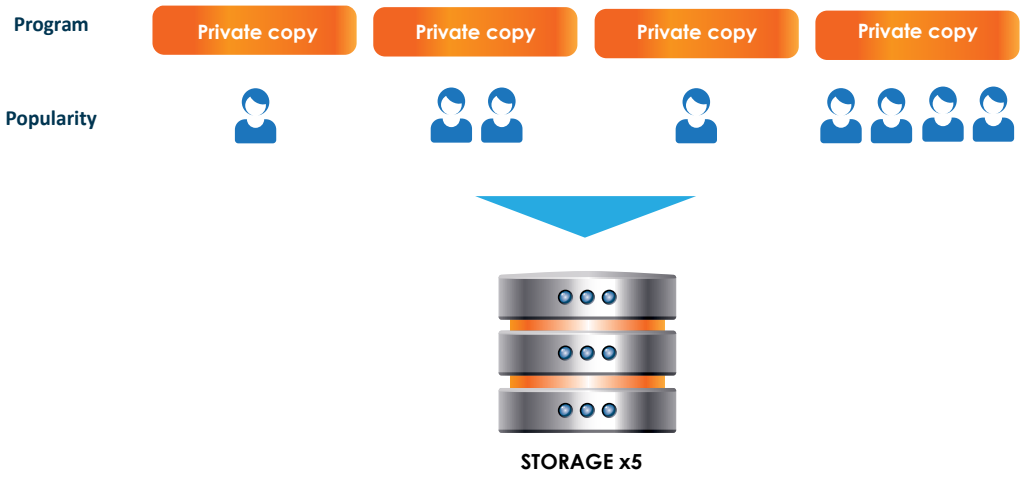
4.3. Flexible and adaptable solution: a strategic issue

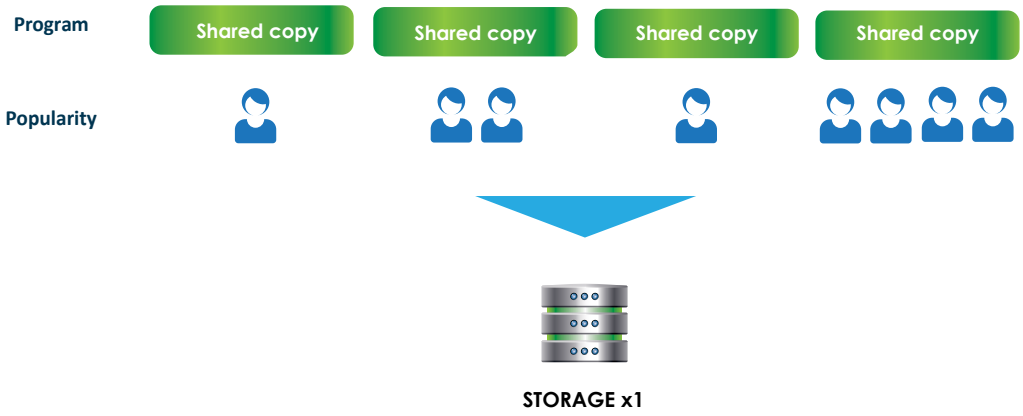
The uncertain legal landscape did not prevent operators in various markets from launching their cloud DVR service. However, choosing the appropriate solution for an upcoming launch requires the ability to manage this uncertainty and anticipate future developments.

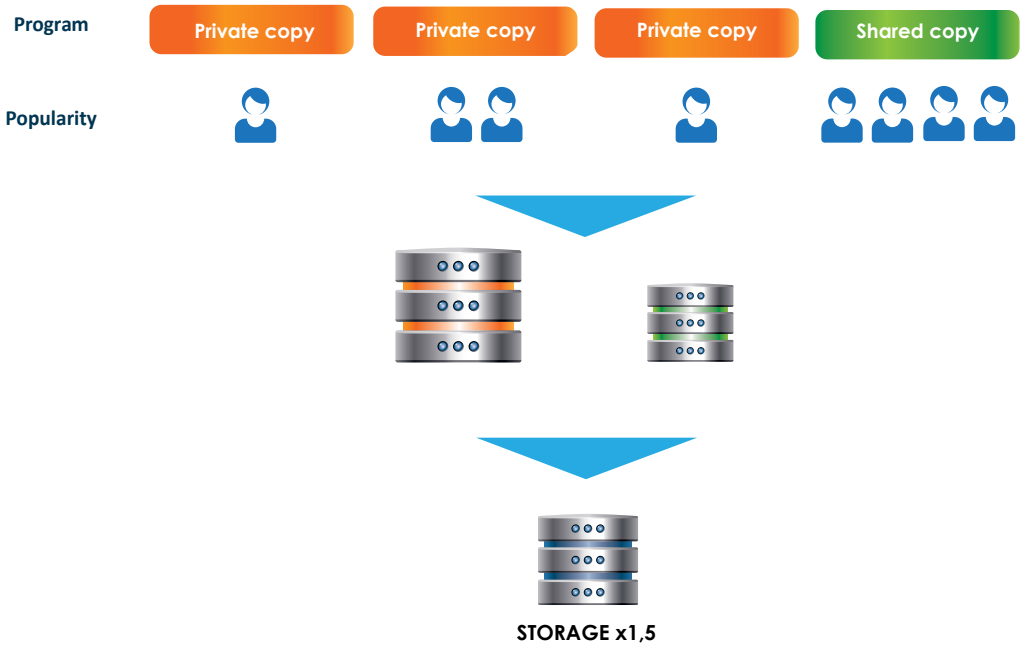
An allowed recording approach (private or shared copy) may vary depending on jurisprudence in a country or on specific agreements with content owners. As both factors may evolve on different paths, a hybrid cloud DVR solution (meaning one which is able to handle both private and shared copy simultaneously) appears to be the wiser choice to manage risk and secure investments.

Not only may recording strategies change over time but the complexity can increase depending on negotiations with content owners. Some companies may start with a private copy approach. Once the regulation and negotiation are in progress, they will be able to switch some channels from private to shared copy.

8. Fees for providing Set-top-box with memory and vPVR– SUISSIMAGE – 2013 – 2016


Program
Private copy
Private copy
Private copy
Private copy
Popularity
STORAGE x5


Program
Shared copy
Shared copy
Shared copy
Shared copy
Popularity
STORAGE x1


Program
Private copy
Private copy
Private copy
Shared copy
Popularity
STORAGE x1,5

This is the simplest case as the cloud DVR system just has to know that channel 1 is in shared copy mode and channel 2 is in unique copy mode. To provide the authorization to do shared copy, channel owners will most likely have to clear the rights with initial content owners. They will probably not be able to clear all the rights at the same time and may therefore authorize the operator to do shared copying on some programs and private copying on others. The recording strategies vary both at a channel level and at a program level (i.e. program A allows shared copy but program B only allows private copy).

The cloud PVR solution provider has to be able to manage this complexity. In addition, the solution has to be flexible enough to let this strategy evolve over the time.

5. How Cloud DVR is creating added value for telecom operators

Besides innovative ambitions for launching a new service and the need to follow the mutation in TV usage, what are the economic reasons for a telecom operator to launch a cloud DVR service?

5.1. A new form of monetization

- An opportunity to monitor capital expenditure and raise average revenue per user (ARPU) :

A traditional hard-disk-based recording service, typically invoiced at 5 $ per month per user represents a 60 $ annual revenue for an operator. Based on a cost of 150 $[9] for each hard drive per set top box deployed, it takes the operator more than 2 years to amortize his recording service. This calculation is simply based on the hard disk cost and does not include possible taxes on storage space and the support and replacement costs of the hard drive in case of failure.

With the cloud approach, there is no need to deploy hard disks in set-top boxes with a storage space that is not always used.

To pursue our calculation, 100,000 set top boxes to be deployed represent an envelope of $ 15 million of CAPEX that can be invested in the cloud DVR platform.

Investing in the cloud approach today is therefore an interesting opportunity for the operator as this platform investment can be mutualized with other services such as catch-up TV, VOD and ‘TV everywhere’. Those services will become a ‘must have’ in the coming 2 years if not already deployed.

When a cloud DVR service is launched, it creates new business models as storage space in the cloud can be charged in various ways (global fee per month, price per channel or bouquet, storage quotas, etc.) and storage capacity can be scaled-up to meet rising user demand and installed base over time.

More than 20 Cloud DVR services have already been launched in Europe, and first feedback indicates it is an opportunity for operators to raise their ARPU and encourage their subscribers to upgrade to premium packages.

- An anti-churn solution

Unlike video recording on a hard drive, Cloud DVR can potentially provide unlimited storage capacity and/or unlimited retention time of recordings.

The recording simplicity, combined with the possibility of access on any device at home or on the move, encourages customers to record and keep a large amount of content and create true virtual video libraries. For a customer, churning to another operator will imply losing all stored content.
The bigger the storage capacity and retention time, the stronger the anti-churn argument becomes over the years. Besides anti-churn, promising an unlimited storage capacity is also a powerful way to acquire new customers.

From the economic standpoint, real CAPEX savings can be realized. At a high level, it boils down to compa-ring HDD storage costs in a constrained device with network delivery costs. On the technical side, while moving recording to the network poses new challenges, they are usually less complex to handle that optimizing STB software to deliver advanced on- demand features.

Simon Trudelle
Nagra, Senior Product Marketing Manager

- A competitive advantage

The Cloud DVR service can be marketed to represent an unbeatable competitive advantage: in the USA, Cablevision[10], for example, chose this service as a workaround to the limited number of tuners inherent to DSL technology. They disrupted incumbent cable companies that offered up to 8 tuners per set-top box.
In Europe, an interesting fact can be observed in the market: each time an operator deploys a cloud DVR service in one country, it is followed within the same year by another operator. Examples are Sunrise and Swisscom in Switzerland, Elisa and TeliaSonera in Finland, Belgacom and Telenet in Belgium, and Telecable and Telefonica in Spain).

5.2. Delivering a unified customer cross-platform experience

A cloud DVR service forms a basis for convergent offers between fixed and mobile services in order to satisfy customer needs at home or on the move. This can be conceived as a bridge to unify TV services. Implementing a global cloud DVR service creates value for the operator on a much larger user base and a mean to develop new services at a larger scale, such as instant replay, catch-up portals or start-over, with no discrimination linked to eligibility of access.

5.3. A better understanding of users

With Cloud DVR, telecom operators and service providers will be able to have access to a lot of data which is usually not accessible with hard drives in a set-top box. Collected data will give them more visibility about usage of the service,

9. Estimating replacement cost of hard drive in a French operator offer

and most importantly, in real time. For instance, they will gain real time information about viewing statistics such as most popular events recorded, replayed, when and what portion of the content is replayed and on which device. Here are few indicators of a European operator that has deployed a cloud DVR service: 80% of viewing requests take place within 24 hours of content broadcast, during primetime hours (8 to 10 pm), 10% of eligible set-top boxes consume 'time-shifted' or 'recorded' content.

In addition to providing a platform that can be utilized to deliver PVR content to a wide range of devices, CloudDVR services also enable support for other time-shifting services such as Catch Up and Restart TV that facilitate a greater level of content discovery than pure linear television can offer

Eric Freund
Minerva, VP Product Marketing

In a technical perspective, cloud DVR analytics will allow operators to optimize their infrastructure and anticipate future evolutions. In a marketing perspective, cloud DVR data can be used to increase customer knowledge and the segmentation of the installed base, in order to increase customer loyalty with targeted promotions or content offers. Coupling these consumption data with data related to the consumed content can also provide meaningful and very valuable insight on consumer tastes and potential buying intentions. These data can be used for targeted ad placement, for instance.

6. Cloud DVR: a foundation for the future

6.1. A promise of new revenues: Premium Targeted Ads

Proposing highly targeted ads for a specific user profile at a specific time in the consumption cycle is gaining popularity on the web and presents a promise of future additional revenues for the TV industry (operators and content owners). In that perspective, there is still a long way to go for a balanced revenue-sharing model to emerge and the ability to sell targeted ads in markets that may be at different maturity levels in that respect.

Utilization of Real-Time Analytics such as Data in Motion capabilities has led to Real Time Targeted Advertisin-g. In the future advertisers will be able to target a specific audience or an individual. An Ad Avail is no longer a single 30 second spot, it is hundreds of thousands of spots across the same Ad Avail.

Michael Clanton
IBM, Global Digital Media Solutions

However, dynamic ad insertion and addressable advertising are opportunities for cloud DVR. They provide the following capabilities:

- Flexibility to swap out ads for monetization of content viewed at any time. This also means the viewer does not have to watch out-dated ads.
- Targeting of ads to specific households based on audience characteristics.
- Optimization of ad loads for the best consumer experience as well as the best monetization potential.
- Use of trick mode (restricts fast forwarding capability) letting content providers/operators control the skipping of advertising in content.

To achieve these business objectives, the capacity of the technical platform to manage ad-insertion on the fly is certainly mandatory. A cloud DVR platform which is able to handle packaging on the fly (see Anevia white paper 'Edge-

10. Optimum Expands Cloud-Based DVR to Include Three Times More Storage and 10 Simultaneous Recordings . Bethpage, NY (PRWEB) July 24, 2013

packaging will be key for guaranteed live OTT distribution with CDNs' for more details) will be able to handle on the fly ad-insertion by design.

Technically speaking, whereas targeting ads accurately is virtually impossible to achieve in a broadcast environment, it is much easier if a cloud DVR solution is already in place for live as well as replayed content. Not all Cloud DVR solutions are able to manage on the fly ad insertion but, provided the solution is able to manage the content in small segments, it will be possible to provide or evolve this kind of personalized ad replacement. Nonetheless, some provisions need to be made in the preparation of content: at least, the beginning and the end of the ad spaces have to be marked in the incoming stream and encoded so that the content can be inserted switched at this point. This is very similar to what is done currently for local ad insertion in broadcast networks. If a compatible Cloud DVR is already in place, there is no extra cost to play targeted ads for replayed content. It consumes no more infrastructure than replaying the content itself. The infrastructure has to be sized up if this strategy is extended so that the ad replacement feature is applied to live content.

Dynamic ad insertion (DAI) is the biggest opportunity for cloud DVR. It provides flexibility to swap out ads for monetization of content viewed at any time. This also means the viewer does not have to watch out-of-date ads. It also provides targeting of ads to specific households based on audience characteristics and control on the skipping of advertising in content.

Chris hock
BlackArrow, Senior Vice President Marketing

This new type of advertising opens up a an extremely large new monetization window extending far beyond the 'post-C3' window, C3 being a unit of measure used by Nielsen to quantify advertising on TV recordings, three days following the live TV broadcast of a program. Advertising will therefore not lose its value when the program is watched weeks or even months after registration as it can be dynamically replaced by continuously relevant advertisements. This new revenue potential, untapped today, becomes an argument to find revenue-sharing agreements with content owners who will therefore find their own interest in deploying cloud DVR services.

For Cloud DVR services, packaging on the fly is a technology that really helps to support the variety of devices, enabling huge storage and bandwidth savings. The next technology to improve further those savings is transcoding on the fly. While this approach is too CPU intensive for the time being, it will be a must- have feature in the near future.

Eric Gallier
Vice President,Marketing
at Thomson Video Networks

6.2. On-the-fly transcoding challenge

Despite the huge potential to save storage and reduce throughput and network requirements, mezzanine content needs to be stored in all resolutions and bitrates required to serve the customer base, typically with 4 or more variants for ABR and 1 or 2 variants for IPTV and cable. If transcoding is moved downstream of the storage, only one version of the content needs to be stored and the profile and bitrate variants could be processed in real-time close to playout or to the edge for delivery. Unfortunately, this is not yet possible because the processing power required to perform these tasks in real time for a large number of sessions is not fully available in a cost effective way. But similarly to storage, computing processing power is advancing rapidly, In the near future, the next optimization could be to move the transcoding downstream of the storage or to the edge, as this can be done today for repackaging.

New proprietary formats like Google VP9, as well as standard formats like H265/HEVC, will continue to emerge. In addition, 4K UHD is becoming significant with the release of content in this display format on popular platforms like Netflix and Amazon Prime Video. Moving the transcoding after the storage, even up to the edge will ease the introduction of these new codecs and avoid the need to re-process the stored content.

6.3. Cloud DVR reduces carbon footprint

Services providers are becoming increasingly involved in strong environmental policies to reduce their carbon footprint. The public is also becoming increasingly aware of these concerns and politics are pushing all the industries in this direction.

A recent publication by the French Federation of Telecom disclosed that customer premises equipment (CPE) consumes around 33% of the total telco-related electricity spending, compared with 60% for the network[11]. Disk drives in set-top boxes account for a large part of its consumption. Storing data in the cloud is much more energy efficient than storing it on CPE.

In addition to directly reducing the consumption of CPE deployed at customers' homes, operators can argue that deploying cloud DVR reduces the global carbon footprint of their services compared to traditional PVR.

As far as CPE is concerned, two interesting trends can be observed on the TV landscape: first, the generalization of internet-connected TVs allowing an interactive experience directly on the TV, and second, the emergence of the HDMI dongle which is tending to replace the operator set-top box.

These innovations prove that consumers are trying to free themselves from the constraints of the set-top box. Allowing video recording in the cloud matches this need to access TV content anywhere, any time, on any device.

Cloud DVR represents for the operators a significant step to handle the future of TV consumption.

> Operators are reaping multiple benefits from Cloud DVR. Not only does it lower their STB investments by eliminating local storage, but it also makes recorded content available on-the-go in a 'multi-device' mode. The fact that content never gets duplicated in a shared copy model makes it a much more eco-friendly, energy- efficient solution.
>
> *Stephane Duboc*
> *Ericsson, Head of TV and Media Practice*
> *France and Maghreb*

11. http://www.fftelecoms.org/ chiffres-cles-du-secteur

7. Annexes

7.1. Glossary

Live TV allows users to view live content anywhere, any time, on any devices.

- Pause TV / Time-shift allows users to pause the channel they are currently watching and resume playing a few minutes later from the point where it was paused. After resuming, users can fast forward to the point where it catches up with the broadcast.

- Start-Over TV / Re-Start TV is the solution if the initial part of a program is missed. Users who tune into a program a few minutes late can watch from its beginning using re-start TV.

- Rewind TV enables replay of the scene just transmitted on the channel being watched: the latest score during a sports broadcast, or a key sequence missed due to a distraction.

- Catch-up TV / Replay TV, Backward EPG makes past content broadcast available for on-demand. In addition to schedule flexibility, catch-up TV enables traditional on-demand control over the playing of the content with pause, fast forward and rewind options.

- Cloud DVR (cDVR, nPVR / RS-DVR / n-DVR) provides a network based personal video recorder. Users can schedule their favorite programs to be recorded for later viewing.

- Targeted advertising is a type of advertising whereby advertisements are placed so as to reach consumers based on various traits such as demographics, purchase history, or observed behavior.
- Electronic Program Guide (EPG) is an application used within digital set-top boxes and some television sets to list current and scheduled TV programs that are or will be available on each channel with broadcast time, program duration, a short summary and review for each program.

- EPG-based recording allows a viewer to record one program quickly and easily using the start and end time coming from the EPG.

- Time based recording allows a viewer to record a specific channel between a start and end time set manually.

- TS/UDP and TS/RTP/UDP designates Transport stream over UDP, RTP or UDP – the typical combination to deliver video streams in the IPTV environment

- ABR is the abbreviation of Adaptive Bitrate, a video delivery method using multi-bitrate streams to adapt to the network conditions. It is also a generic term used to include HLS, Smooth Streaming and Adobe HDS.

For more information, visit: **www.anevia.com**