Flexible Cloud DVR

Accommodating Infrastructures New and Old

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Introduction

Cloud DVR empowers subscribers to schedule recordings of their choice as well as the ability to watch those recordings from anywhere utilizing a number of devices (laptops, desktops, mobile phones and tablets). When a Cloud DVR system is architected properly, an operator can offer Cloud DVR to viewers with enhanced capabilities, such as Catch Up TV service and user-generated content storage, using the same infrastructure.

When an MSO takes in all content through an ingest mechanism and stores it in the cloud, any program can be scheduled and listed in the user's Cloud DVR menu. A variable length buffer can be used to provide Catch Up TV, and that same content repository can be used to deliver and store users' requested recordings to their personal storage lockers for later viewing.

In this white paper, we visit the viewer features, service provider benefits and migration considerations for implementing Cloud DVR and touch on the subject of offering Catch Up TV using the same cloud storage system.

Cloud DVR

Cloud DVR stores recorded content and hosts its delivery mechanisms in the cloud, offering effectively unlimited storage and extending portability to all types of viewing devices. Operators can take advantage of advances in cloud technology to add Cloud DVR capabilities to existing DVR implementations, such that local DVR becomes a seamlessly-accessible subset of the system. As an assortment of operations are becoming virtual, using the cloud for media storage and playback enables operators to modernize their services and expand the viewing opportunities for subscribers.

Basic DVR Workflow

The initial airing of a video TV program or movie in the traditional broadcast model occurs at a pre-arranged time. In the basic DVR model, a scheduler captures the video stream into a variable length buffer and, as requested by users, writes a copy to storage. The video can then be

streamed to viewers at their convenience hours, days or weeks later. So the primary functions of the basic DVR system include:

- User Interface for managing the process
- Scheduling
- Recording
- Storing
- Retrieving

The limitations of STB DVR include restricted storage capacity, no backup in case of disk failure and limited devices and locations for playback.

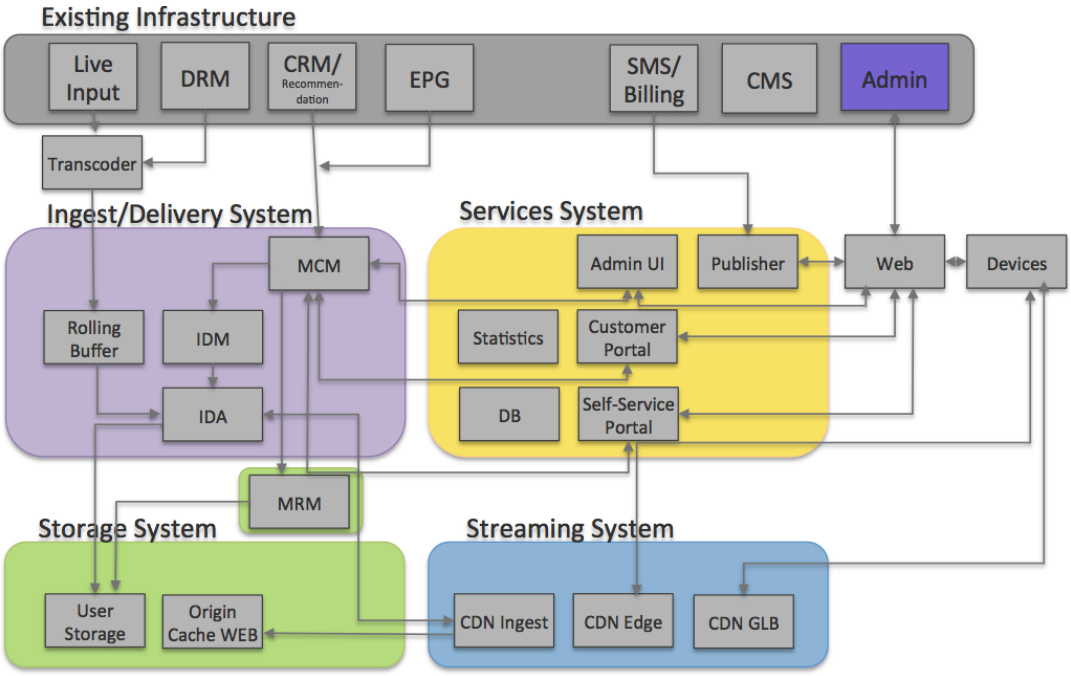
Cloud DVR Workflow

Bringing cloud storage into the workflow introduces nearly unlimited storage capacity and backups, output to any suitable device, and access to content and display devices via the Internet, including the ability to playback anywhere when rights are permitted.

Cloud DVR performs four primary functions:

- Content Ingest
- Services and Management
- Storing
- Streaming

The Cloud DVR workflow extends the basic DVR workflow, taking advantage of cloud-based software that is functionally equivalent to some of the hardware-based processes of the traditional model.



Cloud DVR

The figure shows all of these functions residing in the Cloud. As an assortment of operations are becoming virtual, operators can provide a seamless environment that includes local DVR. Components in the system include a Media Content Manager, an Ingest Delivery Manager which handles recording requests and the Ingest Delivery Agent that ensures content is stored as requested.

One advantage of a purely cloud-based architecture is its scalability. While vastly expandable cloud-storage is a much-touted and familiar concept, an important and often overlooked advantage accrues from hosting streaming functions in the cloud. These compute-intensive operations can better respond to spikes in load demand when based in the cloud, where additional servers can be brought online as needed, then dispensed with when demand subsides.

The Cloud DVR model can support transcoding and storage to many alternative formats, thanks to the number of resources that can be devoted to content ingestion. This allows considerable flexibility with regard to integrating with a particular provider's existing infrastructure. In addition, technology trends are emerging that optimize storage by maintaining content in a mezzanine format, such as MPEG-TS, that is widely understood by a variety of devices or can be readily transcoded and encrypted for output into a device-specific format such as Apple's HLS (HTTP Live Streaming). Besides providing a more economic storage

model, this also means there is no wastage of bandwidth in sending high quality formats that mobile devices cannot render.

Metadata is fed into the system from the MSO's guide data partner and stored as data. This is matched to the content as it is recorded and paired when delivered for either browsing the record list or playing back the content. In addition, specific information can be stored about viewing status per user (not account) so one can tell if they have viewed, partially viewed or not viewed the recorded content. This allows a single copy for an account with different viewing behavior tracked, so that all persons on an account don't have to watch content at the same time.

An appropriately designed UI can provide a uniform means of access across multiple devices, allowing for similarity of operation and viewer convenience. Devices that are equipped with browsers can offer web-based or native portals for users to manage content, where a touch-screen or keyboard-based UI may be easier to use than a TV remote.

Operators can follow user activity, both in UI/Guide usage and in stream-viewing behavior, to inform targeted advertising and content suggestion choices and to optimize content management—keeping popular titles readily available, for example.

From a networking point of view, the Cloud DVR model consists of a control plane and a media plane, where the control plane manages the user, devices, metadata and work flow of the stored videos and the media plane processes and serves up content:

- Control plane - the high-level path from capture to storage to management to delivery. Obtains user selections from the Guide or UI and transmits the information to the Media plane. The Control plane also tracks statistics to provide meaningful behavioral data back to the MSO for making important content acquisition decsions.
- Media plane - means of capture, format of storage, details of management with regard to single/multiple copies, delivery techniques such as edge transcoding targeting specific devices.

Many MSOs already have much of the media plane infrastructure in place. So with minimal reinvestment, many alternatives are available to suit an operator's specific scope and goals, allowing plenty of architectural options at the control plane level.

For example, there are choices regarding when to transcode and encode, which formats to store, and which formats and DRMs/encryption schemes to deliver 'on-the-fly' at viewing time.

Whether a program has been recorded at viewer request or as provider policy, the recording can be stored in a single mezzanine format such as

HLS, then transcoded on output, depending on the viewing device. Because of the cost of storage, many operators choose to store one copy for the user and transcode to the playout copy at the CDN.

Architectural Flexibility

A variety of output buffering approaches mean that timing of content delivery is also greatly improved in the Cloud DVR model. During live playout, the stream is buffered and transcoded. Buffering and fast on-the-fly transcoding allow content to be retrieved nearly in real time, enabling such viewer favorites as live trick play and catch-up viewing.

The system can deliver the stream to viewers as:

- A time-shifted program: The viewer records now and watches later, the 'traditional' DVR usage.
- Catch Up TV: The viewer joins a live show in progress but opts to watch from the beginning, behind real-time in a window dependent on the length of the buffer. In some cases it may be a short window of 90 minutes; in others it could be days to allow for a bigger window of playback without having to store a copy for the user.
- Live Pause: The viewer, watching a live stream in real-time, pauses briefly to do something else, then resumes where he or she left off. Live pause is especially well-suited to watching sporting events.

Catch Up TV is a service similar to VOD in which the provider selects shows to be archived for a limited period, during which time they are available to subscribers for on-demand viewing. The time frame the provider selects, in the range from about 90 minutes to as much as 30 days, constitutes a 'rolling buffer' that remains fixed in duration as expired content is deleted and new shows are added. Consider the possibility of having this rolling buffer's retention time based on the type of content: for example a longer buffer for a popular series, or a shorter buffer for shows that might go stale sooner, such as some sporting events.

Catch UP TV implementations can also offer different times of first availability. The content originator of a popular drama may request a full-day delay before making the latest episode available, whereas a sporting event might be viewable in near-real-time. Users have found Catch Up TV an attractive option thanks to its convenience. Viewers are not required to anticipate their interest in advance to schedule a recording; instead, they can expect the provider to offer a wide selection of popular content for on-demand viewing.

Viewer Features

The ability to record programs in the cloud and deliver the content back to end-users is a relatively new technology, but one that is maturing nicely and ready for implementation. The good news is that for users, scheduling, viewing and managing recorded programs is just as easy and intuitive as using a local storage device. In fact, viewers can take advantage of new innovative features when they use a Cloud DVR solution:

Multi-Channel Recording

Cloud-based DVR is not limited to the number of tuners in the set-top-box. The viewer can record multiple shows at one time and still watch one program. Time shift buffering (rewind or pause live TV) is still available when using a Cloud DVR service.

Unlimited Storage

The DVR function is no longer tied to the amount of storage in the STB. When taking advantage of cloud storage, users can enjoy virtually unlimited storage capacity when offered by a service provider.

Single Library of Content

Some systems provide the ability to store user-generated content in the same cloud location, making a complete repository for their video library. In this scenario, the user experience is improved as users do not lose their favorite recordings in a hard-drive failure.

TV Everywhere Viewing Experience

As with STB DVR, Cloud storage enables multiple device viewing and scheduling, providing the ability to stream to any device in any location when content rights allow.

Bookmarking

A cloud-based system can track where the viewer left off in a show or in a series of episodes and resume playback from that point.

Service Provider Benefits

Cloud DVR offers cost savings and additional income opportunities for the service provider.

Capital cost savings

Maintaining a fleet of in-home set-top boxes is an enormous burden, particularly STBs with the on-board hard drives required to support STB-based DVR functionality, as the hard drive is the most-frequently-failing component. Much of this expense can be reduced with a shift to Cloud-based DVR. An STB without a hard drive has a much lower initial cost, and requires less maintenance.

Personalization for Viewers

The data gathering abilities of the Cloud DVR model provide opportunities for targeted ad insertion. The insights gained by analyzing user profiles combined with time-shifted viewing create opportunities to insert ads that are better targeted to the individual household. It is possible to disable skipping at pre-roll or at the first commercial break.

Operators also benefit from offering extended services made possible by cloud-based capabilities, such as recommendations based on user profile and past viewing habits, upload of personal content, and charge for extended storage.

Transportable Library

Cloud storage is more transportable than STB HDD storage, so if the viewer changes out an STB there are no concerns about losing content.

In practice, a user might have some STB storage and some cloud storage. Essentially, the user interaction and location for storage can be transparent to the user for scheduling recordings and retrieving for playback. The recording manifest and interface logic can be kept in both locations for ease of use.

Migration Considerations

While the migration of DVR services to the cloud offers many compelling advantages, the shift of services from local to cloud storage presents a number of decisions that need to be made for creating this new system. Some considerations have to do with technical aspects of migrating to the cloud-based model, others have more to do with the context in which operators conduct their business, such as business models and legal requirements.

Working with Existing Infrastructure

Virtualization of processing and storage functions allow a shift from specialized devices to high-preformance generic hardware, which cloud services providers offer in abundance. However some operators may want to treat their storage as Network DVR, where they determine to build a private cloud, maintaining their own hardware infrastructure. Operators can choose where in the delivery chain to apply these advantages.

Practically speaking, most operators already offer some kind of recording and replay capability; few will be seeking a fresh-from-scratch Cloud DVR implementation. Both operators and viewers will probably prefer some sort of overlay solution, in which Cloud DVR is offered with existing services and integrates with existing infrastructure. Cloud implementations based on open architecture and open APIs can be almost entirely hardware agnostic, and are thus well-adapted to hybrid schemes.

The ability of the viewer to upload recorded programs from their local storage to cloud storage could be a very desirable feature. A viewer friendly hybrid migration plan will offer a means to replace DVR boxes and keep the content. This will entail addressing content security and legal requirements.

Bandwidth

Traditional STB-based DVR offered unimpeded delivery from the STB to its connected TV, but the connection was entirely local to the home, often to the same room in the home. Delivering a cloud-based "anytime, anywhere" viewing experience means the provider must find strategies to supply its subscribers with pipelines to support streaming from the cloud to the destination. As operators extend viewing rights of content, they can extend the locations in which subscribers can view the content, for

example by negotiating rights out of market by contracting with Content Delivery Networks (CDNs) or other providers.

Scalability

Scalability is based on both the number of users supported per CPU and on the number of CPUs available. Cloud-based DVR offers ease of future upgrades and replacements.

Cloud DVR provides the ability to scale the solution as channels and services are added. Because many cloud components are software-based, the provider is not locked into proprietary platforms, allowing operators to test and grow without a huge outlay at the beginning. This flexibility enables the operator to easily increase transcoding capacity by adding five new streams, for example, to address growth. The operational and capital expenses associated with maintaining and expanding a data center for media storage, including hardware maintenance and upgrades, staffing requirements, environmental controls, and space requirements, are now the concern of the cloud services provider, so the operator can respond quickly and efficiently to consumer demand by simply placing a request.

A cloud-based implementation will be able to handle large-magnitude spikes in demand, such as those generated by the Super Bowl or the FIFA World Cup. An event of this size generates a high demand for non-simultaneous playout to a massive number of users. Servers are needed not only for storage, but as hosts for the software components that ingest the live stream and subsequently transcode it for delivery. A true cloud solution can allocate a large number of servers and CDN resources for short periods of time to handle such demands, and then release the resources.

One strategy that can improve the efficiency of moving files to storage is to offer a viewing window of 2 to 3 days, providing some relief to the offloading of the live stream to each user's storage. If during that window a viewer requests playback and it has not been committed to their storage location, when legally viable, the cloud-based buffer stream can be used for playback.

Service Model

Cloud DVR offers some flexibility with regard to service definitions not afforded by local DVR. In the Catch Up model, providers record all content and make it available to subscribers in (for example) a 30 day rolling buffer, so viewers have 30 days to catch up, but may never

actually implement user-based storage. Other providers offer time-based storage per piece of content. For example, a specific piece of content can be timestamped, and its playback restricted to a set timeframe. Such provisions give operators flexibility in dealing with content rights on a show-by-show basis. Capabilities already described, such as purchasing extra storage and uploading personal DVR content to the cloud, can also figure into the business model. Legal constraints on some of these strategies differ from one country to another.

A software based Cloud DVR solution is infrastructure-agnostic; that is, it does not force specific hardware or cloud infrastructure. Cloud DVR technology suppliers can bundle its 'commodity' component services (transcoding the live stream coming in, processing with a rolling buffer, delivering to user storage and CDN, metadata handling, device management), in a way that supports provider independence and preserves the ability to integrate with existing infrastructure using multiple vendors.

From both the business and engineering perspectives, Cloud DVR offers potential synergies for integration with VOD services. For example, viewers who have recorded some episodes of a TV series might be able to purchase episodes they have not recorded. The single-copy versus shared-copy issue described below is another possibility. Such optimizations, however, must be considered carefully to ensure the operator has honored content ownership and legal responsibilities.

Legal Issues

Some legal issues arise regarding the storage of content in the Cloud. Content originators' rights must be protected, not only from a security standpoint, but in compliance with laws and regulations in the service areas.

For example, in the US and some other countries, the operator must store a single copy of each recorded program for every user request. This is known as the "single copy" requirement. Technically, one shared copy can service many individual viewers, and there are some efficiencies to be gained by this approach. In some jurisdictions, it may be legal to service viewers with a single copy while, at the same time, retaining a single-copy-per-viewer to comply with regulations. Each MSO must determine what they feel will meet the legal standard.

Other implementation strategies that might be required to comply with content owner requirements include shared/unique storage, blocking

recording on a per channel/program basis, and content expiration from storage and CDN.

Summary

Cloud DVR provides the familiar (and expected) DVR functionality—record and playback—within an expanded context, so operators can provide this much-demanded service with additional recording and retrieval features such as encoding for multiple output devices, accessibility outside the provider's service area, catch-up viewing and live pause capabilities.

The model's versatility allows operators to implement additional capabilities, such as Catch Up TV service, using the same infrastructure.

Alticast provides a Cloud DVR system that can be dovetailed into existing infrastructures, managing the complex workflows for storage and retrieval while also providing critical user behavior data back to the operator. These services allow the operator to extend services to its users and continue to finely personalize those services to each individual. This unique service to the users enhances their viewing experience, while broadening the business opportunities for the operator.

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Alticast provides AltiPlex Cloud DVR with a web-based Admin Console for management. AltiPlex Cloud DVR can plug and play with existing infrastructure. It is a software-based solution that allows providers to use any hardware that they choose. The provider can partner with a CDN or use their existing storage infrastructure. Similarly, the provider can utilize their own transcoders or buy services from a third party or Alticast partner.

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