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Head End Transformation to Meet the Content Delivery Demands in Multiple Screens

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Abstract—Need for a comprehensive video solution arises to meet the demands from big screens to small screens with continuous evolution of products and technologies. Apart from meeting this demand, the trend of consumer's viewing habits also get drastic changes which drive the transformation of Head end to cater traditional STBs to latest handheld devices. This paper explains the transformation from traditional head end to the modern architecture leveraging the benefits from Content Delivery Networks

Keywords— Head end, Content Delivery Network, IPTV, Cloud based CDN, Velocix

I. Introduction

The requirements and needs of our customers and customer's customers are changing rapidly with respect to time and technology evolution. The penetration, diversity and usage of various hand held devices like mobile phones, Tablets, Android devices, iOS devices, etc in addition to traditional PCs, laptops and TV screens has increased the demands in media streams to suit different resolution screens, different bit rates, etc

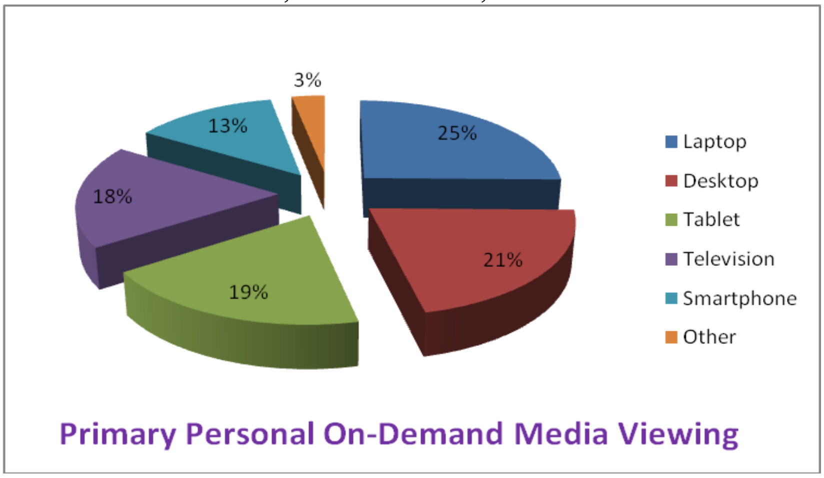

Fig. 1: Distribution of devices usage for On-Demand Content

The pie diagram from Fig.1 shows that the viewers of Television are overtaken by Laptop, Desktop and Tablet devices that creates a new demand to have content delivered on the move [1]. This drives the service providers to transform from traditional providers of access-based services to "any-time, anywhere" media providers. In this transformation, it's essential to leverage the advantages provided by technological developments in cloud concepts for the storage and delivery of contents.

While the efforts are ongoing to enhance the Video Streaming Quality of Experience from the Head end components, there is also other side that facilitates the delivery of Video Streams to the end users. Yes, the network capability also plays key role in the delivering the Video Streams to the end users with highest possible quality.

Customers expect maximum picture quality with high reliability and latest features using advanced techniques that will utilize available bandwidth to the maximum thereby reducing their expenses and increase the customer satisfaction.

II. Multi Screen Head End Architecture

The traditional Head end architecture as shown in Fig.2 depends on processing components connected via Serial Digital Interface (SDI) or asynchronous serial interface (ASI) video routers, the professional standards used in the digital TV broadcast industry. Headend components are also located in a common physical place, interconnected using coaxial cables, and established via predefined, almost static, connection routes.

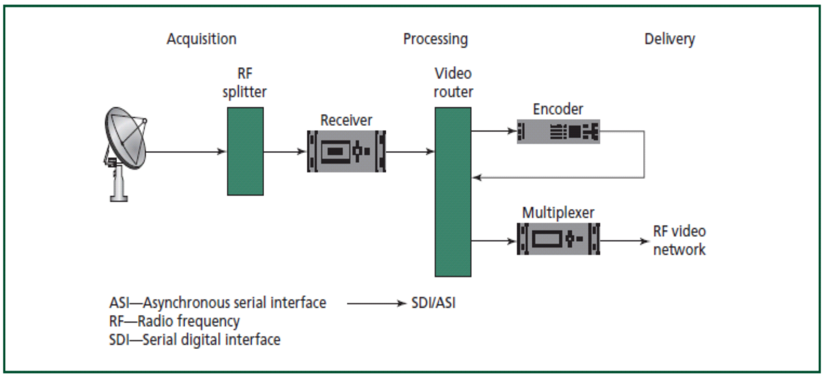

Fig 2 Traditional headend architecture.

The next generation headends are moving towards an IP-based converged architecture where the elements are located in the cloud in a service-oriented architecture (SOA) and each element provides one or several services in the processing chain [5]. An SOA approach will facilitate the management of the headend through auto discovery. Typically, when a new device is made available, it will publish its existence along with the services that it provides. Element managers/load balancers can account for the presence of new devices automatically to leverage their functionality and integrate it into the processing workflow as shown in Figure 3.

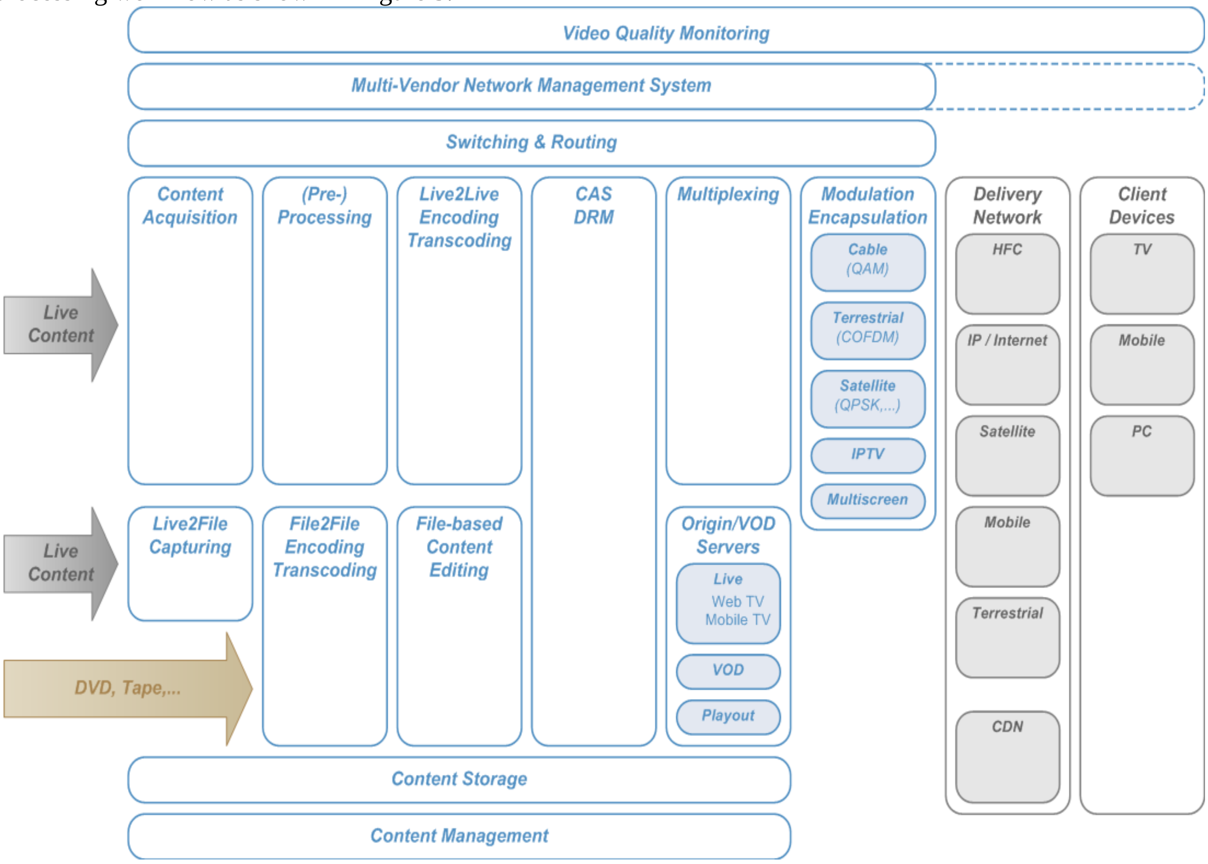

Fig 3 Modern headend architecture.

A. Content Acquisition

The live content is received by the professional Antennas (example C-band, Ku band, etc based on the downlink frequency) tuned towards respective transponder azimuth and elevation so as to receive the DVB-S, S2 signals. These Radio frequency signals are fed to the Integrated Receiver / Decoder (IRD) that picks up the digital information transmitted in it. This digital information is passed through ASI/SDI interfaces or IP interfaces. For VOD applications, the live content is archived into the required file formats and stored in the VOD servers.

B. Pre-Processing/Encoding/Transcoding

The content that we get from IRD needs to have certain processing and encoding done based on the Head end stream design, input content, output requirements, type of clients used, etc. This includes the deinterlacing to process interlaced video sources such as 1080i, scaling, color space down sampling/conversion, smoothing filter to reduce the PSNR based on input bit rates. Transcoding is used to convert the incoming baseband or IP digital video content to a series of output bit-rates suitable for the target client device.

C. CAS/DRM

Conditional Access Systems (CAS) and Digital rights management (DRM) technologies provide content protection (copy prevention) and revenue protection (blocking access to unauthorized users) for video content.

CAS is the protection of content by requiring certain criteria to be met before granting access to this content. This is achieved by a combination of Scrambler and Encryption. The data stream is scrambled with a 48-bit secret key, called the control word. Knowing the value of the control word at a given moment is of relatively little value, as under normal conditions, content providers will change the control word several times per minute. The control word is generated automatically in such a way that successive values are not usually predictable; the DVB specification recommends using a physical process for that.

In order for the receiver to unscramble the data stream, it must be permanently informed about the current value of the control word. In practice, it must be informed slightly in advance, so that no viewing interruption occurs. Encryption is used to protect the control word during transmission to the receiver: the control word is encrypted as an entitlement control message (ECM). The CA subsystem in the receiver will decrypt the control word only when authorized to do so; that authority is sent to the receiver in the form of an entitlement management message (EMM). The EMMs are specific to each subscriber, as identified by the smart card in his receiver, or to groups of subscribers, and are issued much less frequently than ECMs, at regular intervals. The contents of ECMs and EMMs are not standardized and as such they depend on the conditional access system being used. The control word can be transmitted through different ECMs at once. This allows the use of several conditional access systems at the same time, a DVB feature called simulcrypt, which saves bandwidth and encourages multiplex operators to cooperate.

Digital Rights Management (DRM) is the integral part of end-to-end content protection technology. It will take control of encryption, key management and user right provisioning. DRM technologies attempt to give control to the seller of digital content or devices after it has been given to a consumer. For digital content this means preventing the consumer access, denying the user the ability to copy the content or converting it to other formats. There are many DRM vendors, technologies, and often have complex legalities of licenses and royalties, branding and content owner audits etc.

D. Multiplexing/Modulation/Encapsulation

Multiplexing is the method by which multiple streams are combined over a shared medium. Statistical Multiplexing (Stat Mux) is widely used feature as it allows the bandwidth to be divided arbitrarily among a variable number of channels (while the number of channels and the channel data rate are fixed in TDM). Hence this will avoid slot wastages and increases the link utilization factor. The transmission capacity of the link will be shared by only those users who have packets.

Modulation is the process whereby some characteristic of one wave (carrier signal, which contains the information, to be transmitted) is varied in accordance with some characteristic of another wave (modulating signal). Different modulation techniques are used based on the transmission carrier and applications. For example, Quadrature Amplitude Modulation (QAM) is used for cable transmission; Coded Orthogonal Frequency Division Multiplexing (COFDM) is used for Terrestrial; Quadrature Phase Shift Keying (QPSK) for Satellite transmission**.**

Encapsulation is a method of designing modular communication protocols in which logically separate functions in the network are abstracted from their underlying structures by inclusion or information hiding within higher level objects. The transport streams specifies a container format encapsulating packetized elementary streams, with error correction and stream synchronization features for maintaining transmission integrity when the signal is degraded. Thus the transport streams carries Program id (PID), Programs single (SPTS) or multiple (MPTS), Program Specific Information (PSI) that includes Program Associate Table (PAT) and Program Map Table (PMT)), Program Clock Reference (PCR), null packets apart from the Payload.

E. Content Storage / Content Management

The video assets are stored in origin server and using streaming protocols like Apache, Webdav, Microsoft IIS the contents are streamed. The content management system normally takes care of video ingest, managing video libraries, workflow management on specific tasks basis (including getting the needed transcoded files), asset delivery, content security, customized publishing, playback security, file processing, analytics and reporting. Cloud Digital Video Recorder (C-DVR) is used for content storage and distribution using the Cloud technology.

F. Delivery Network / Client Devices

Delivery network is basically the distribution system that delivers the video assets from Head end servers to the client devices. This network varies based upon the carrier medium. Due to the technological advancements, the content delivery networks also started using the cloud technologies.

Client devices are pointing the end user devices like PC, Laptop, Mobile devices, Android, iOS devices, TV, etc. The video assets are transcoded according to the client profiles and get streamed (HLS, SS, MBR, MPEG-TS, RTP, RTSP,etc) to these devices. With the varieties of hand held devices, we get 3 different profiles of H.264- Baseline, Main and High.

Generally speaking, the older the target device, the less CPU and, therefore, playback power it has. It's harder to generalize about Android capabilities, because of the sheer number of devices. However, the modern, top-of-the-line Android devices at the very least support what the iPhone 4 does. These profiles and corresponding H.264 Levels are used to classify specific client playback capabilities. While these devices do not have a standard High Definition sized screen, some are able to output standard HD and SD resolutions to a television using Digital AV Adapter or VGA Adapter.

The older devices (e.g. iPhone1 to 3GS, Older IPOD touch, etc) were mostly using the display size of 480x320. Accordingly the profiles used were:

H.264 video, Level 3.0, Baseline profile
AAC audio, 1-2 channels
Max Frame Rate: 30
Video Bitrate: Up to 1.5Mbps
Audio Bitrate: Up to 160Kbps
Audio Sample Rate: 48000 or less

The current devices (iOS, Android based) have variety of display size and resolution, which includes:

1) *iOS Screen Display Sizes:*
   iPhone/iPod (960x640), iPad (1024x768), Apple TV (1280x720), iPhone 4 (960x640), iPhone 5 (1136x640), iPad 2 (1024x768), Retina (2048x1536), Mini (1024x768)
2) *Android Screen Display Sizes:*
   Nexus 4 (1280x768), Nexus 7, Samsung Galaxy Note (1280x800), Nexus 10 (2560x1600), Samsung Galaxy S3 (1280x720), Motorola Razr V (960x540), HTC Droid DNA, LG Optimus G Pro (1920x1080)

The profiles used for these current devices are [2] :
H.264 video, Level 3.1, Main profile
AAC audio, 1-2 channels
Max Frame Rate: 30
Video Bitrate: Up to 5Mbps
Audio Bitrate: Up to 160Kbps
Audio Sample rate: 48000 or less

Thus the modern Head end architecture provides the media streams of multiple profiles and streaming protocols according to the requirements of variety of hand held devices. Next we will see little deeper on how the IPTV solutions utilizes the cloud technology in Content Storage and Delivery and the benefits brought by them.

III. INTRODUCTION TO CLOUD BASED IPTV SERVICES

It is important to define what cloud-based TV services are and what they are not. In recent years, the term "cloud" or "cloud computing" has become more popular, especially among consumers. But businesses are also starting to see the word cloud enter into B2B applications. The cloud is simply another term for hardware and software services that are delivered as a managed service over a network, usually the public Internet. Cloud-based TV services are then services that are typically outside a TV operator's plant. Instead of procuring, buying, installing, maintaining and servicing hardware equipment, for example, and licensing and acquiring software, TV operators can instead subscribe to a service.

As a result, IT services can be procured as a per-per-use or pay-as-you-go model. In effect, a company pays only for the amount of services that it is actually consuming at any given point of time. Capital expenditure, or capex, is reduced significantly and can be converted to operating expenditure, which can benefit many companies.

As cloud computing has become more popular, this has also led to the emergence and popularity of cloud-based TV services. The kinds of applications and services that can be offered via the cloud are increasing every day

A. Content Delivery and Storage using Cloud

The marketplace is clearly looking for something beyond the sofa experience. Modern life styles demand it. Customers now want to look at more than just content on their beautiful large screen TVs. They want to watch content everywhere, and enjoy the content of their choice wherever they are and whenever they want it. This we will call as "Content Everywhere".

Operators & content owners are naturally trying to use this opportunity and are incorporating multi-screen delivery experience in their strategy. Aside from matching customer's requirements, this new strategy adoption is an efficient way to secure subscribers bases. Indeed, subscribers used to pay a fee every month for content (live and offline) to the operators. In the past, when subscribers were out-of-home, they could not enjoy the content they paid for any longer. Now within the multi devices and locations strategy, subscribers can have the benefit of watching video wherever they are [4].

B. Content Everywhere using Cloud

One step to achieve content everywhere is to bring the content closer to the user's device. Growing consumption is raising pressure on service providers' fixed and wireless networks. To ensure network performance and maintain an effective network cost base, service providers are deploying content delivery networks (CDNs).

On-net CDNs offer scalable, cost-effective support for a broad range of content delivery capabilities. For example, they can deliver high-volume video traffic, distribute software updates that involve a large number of transactions and accelerate the performance of Web sites and applications. By creating their own CDNs, service providers can minimize the distance that content travels over the network and deliver it more quickly and reliably. As shown in Figure 4, on-net CDNs originate content at the edge of fixed and mobile networks, bringing it closer to consumers. This proximity to consumers helps service providers reduce congestion and disruptions and deliver a consistently superior quality of experience (QoE) to subscribers [3].

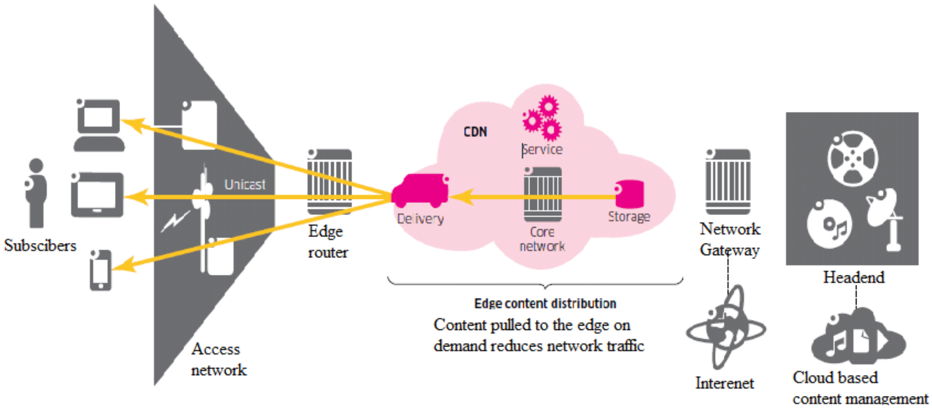

Fig 4.On-net CDNs bring content closer to the consumers.

C. *Velocix shared CDN*

Apart from having its own middleware and other IPTV solutions, Alcatel-Lucent comes with a content delivery solution called Velocix, to help operators build and operate their own internal CDN. Velocix lives inside the operator's network and gives them information on what's happening from the head-end to the home.

Velocix includes a cloud-based offering but it does also include some hardware that lives inside the network. The solution includes a back office implementation from thePlatform for handling workflow or even encoding, HTML5-based media players for multiple devices, some hardware and the new enhanced video experience (EVE) solution. EVE allows operators to manage their entire network, including directing better quality to different devices, managing bandwidth, content preferences and even custom advertising.

The deployment scenario, illustrated in Figure 5, leverages multi-tenancy capabilities already provided by the Velocix solution. It can supply all service functions including request routing, cache selection, management, monitoring, configuration and deployment as an optional managed service. Alternatively, these service functions can be provided by one of the service providers. Storage functions (origin server, storage and publishing) can as well be hosted either by service providers. Each service provider has control of its own CDN customer base and all delivery functions. At the same time, each service provider can share the benefits of content delivery that is common to all.

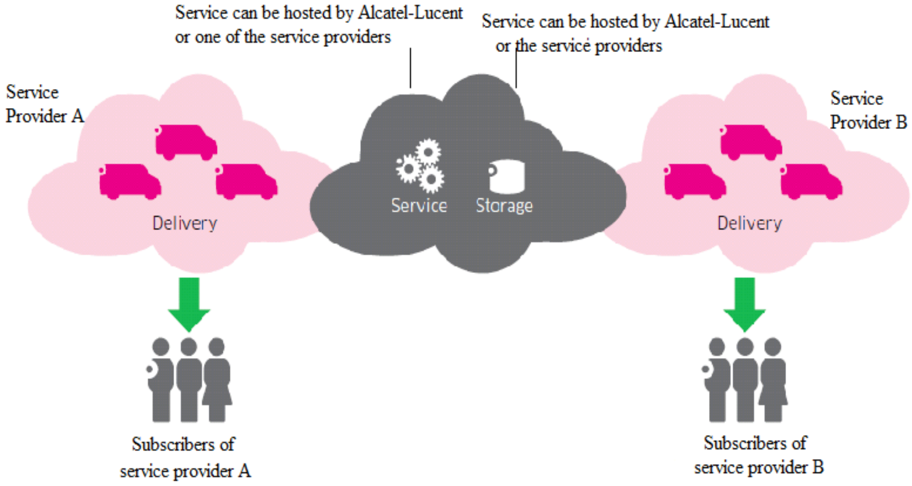

Fig 5.Velocix shared CDN in production environment

The Velocix CDN uses multiple administrative layers to support a flexible approach to a shared CDN. As shown in Figure 6, the solution can establish a scheme to generate virtual CDNs that share the same delivery appliances. Each virtual CDN can configure separate accounts for different customers. Each customer, in turn, can configure separate accounts for different services. These flexible hierarchies can scale readily to support scenarios that include many virtual CDNs, customers, services, publishers and objects.

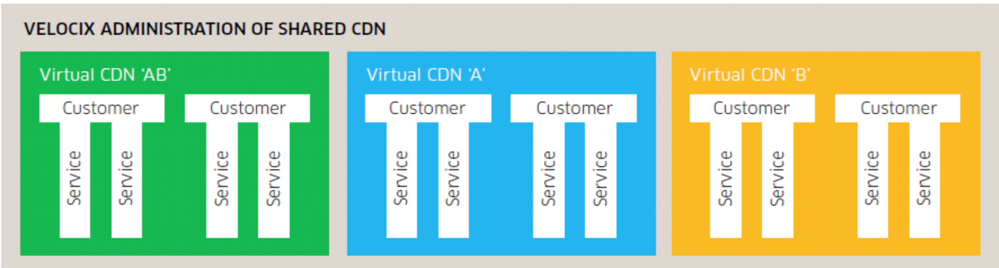

Fig 6.Velocix shared CDN hierarchy

The Velocix CDN offers a rich role-based administrative model that complements support for shared virtual CDN, customer and service hierarchies. This model allows service providers to control administrative access between virtual CDN domains, customers and services.

D. Velocix APIs

The Velocix CDN offers a broad range of extensible, flexible and openly available APIs. Service providers can use these APIs to support many different use cases, including the shared CDN scenario described in the preceding section, and to gain experience with the principles of CDN interconnection and federation.

The Velocix CDN includes the following APIs:

1) Velocix Server Side Cache Selection API:

This API enables external systems to request cache selection information. Systems can receive request routing information from this API by passing it a parameter such as an end-user IP address. The response includes the best cache to use. Content providers and service providers can use this API in a variety of ways, for example, to build applications that construct playlists or to provide a CDN selector with request routing instructions.

2) Velocix Provisioning API:

This API enables external systems to manage (create, delete and modify) resources such as Web sites, origins and users within the CDN. In shared CDN deployments, it allows content and service providers to use their own management systems to provision services on the Velocix CDN.

3) Velocix Publishing & Acquisition API:

This API enables content and service providers to publish assets directly to the CDN using a broad range of industry-standard publishing protocols. Supported protocols include Aspera, rsync, FTP, SFTP, HTTP PUT/PUSH, XML-RPC pre-publish over SSL, and reverse proxy to external origin servers.

4) Velocix Authorisation API:

This API allows service providers to use an external authorization server to authorize requests for content and influence how the content is delivered. In a shared CDN scenario, for example, the down-CDN (dCDN) may make requests to an authorization server to understand how it should respond to requests delegated by the up-CDN (uCDN) such as requests for encryption keys.

5) Velocix Control API:

This API allows a content or service provider to control Web site objects by way of a programmatic interface. For example, a content provider can flush or delete objects from the Velocix CDN, either to remove invalid objects or to ensure that the CDN has the most current version of a given object

6) Velocix Reporting API:

This API provides an Atom-based interface that gives service and content providers programmatic access to CDN logging data and event-based reporting capabilities. Reports can be filtered in the Velocix CDN to provide output relevant to specific users within service or content provider organizations

These APIs provide a foundation for meeting the requirements set out by the CDN interoperability standards

IV. CONCLUSIONS

In this paper we had seen the transformation of Multi screen head end modern architecture from the traditional ones and discussed how the head end architecture makes use of cloud technologies towards content storage and distribution to the variety of clients. We had seen Cloud based IPTV solutions, for content delivery and storage with little more details of Cloud based CDN, Velocix.

The journey is continuous and still evolution exists in rapid pace as new technologies, requirements, consumer devices flood the market raising the expectation of high quality viewing experience. Hence the efforts are still ongoing to improve the viewer experience QoE and the experiments are ongoing to try to increase the utilization of link bandwidth.

V. ABBREVIATION

ASI - Asynchronous Serial Interface
CAS -Conditional Access Systems
CDN -Content Delivery Networks
DRM -Digital Rights Management
DVB -Digital Video Broadcasting
DVB-S -Digital Video Broadcasting – Satellite
HD -High Definition
IRD -Integrated Receiver / Decoder
MPTS - Multiple Program Transport Stream
SPTS -Single Program Transport Stream
SDI -Serial Digital Interface
VOD -Video On Demand

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