SCTE CABLE-TEC EXPO '14
SEPTEMBER 22-25 / DENVER, CO

SCTE Society of Cable Telecommunications Engineers

Commercial IPTV Architectures

A Technical Paper prepared for the Society of Cable Telecommunications Engineers
By

Glen Hardin
Senior Director, Video Systems
Time Warner Cable
7910 Crescent Executive Dr., Charlotte, NC 28217
704-731-3289
glen.hardin@twcable.com

Niem Dang
Principle Engineer, Video Infrastructure and Architecture
Time Warner Cable
13820 Sunrise Valley Dr., Herndon, VA 20171
703-345-3101
niem.dang@twcable.com

Commercial IPTV Architectures

Commercial Markets are one of the largest untapped segments for video revenue streams. However, televisions are not always the accepted norm or desired viewing device in these environments but with the advent of IPTV and delivery to multiple screens the barrier to capitalize this market segment primarily focused on:

- The Enterprise – Desktop streaming of customized content packages
- College Campus – Large Bulk Video Customers for Alternative Screens across multiple networks
- Hotels & Bars – Optimum Opportunity for 4K Video and Early Adopters
- Applications in Residential

Where as in the residential market, IPTV implementations represent a second optional alternative screen; in Commercial Markets the IPTV solution would be a Primary Video Service to a very discerning and demanding customer. Frankly speaking, "best effort" and client-side determination of video quality is not a viable product offering for these markets.

Contrary to belief, the new IPTV paradigm does not negate the lessons learned from "classic video" but clearly emphasizes the need to apply them to as the demands of this market represent a significant shift in the basic premise of IPTV and its current incarnations and to be able to generate revenue and monetize the investment in the client and CDN infrastructures

At the core of most IPTV Adaptive Bit Rate (ABR) solutions is the notion that "client-side-initiated video streaming optimization, this inherent "HTTP Get" of segmented video can create a client-side-chaos of video delivery and on the whole a less than optimal customer experience. Furthermore, the customer's network administer is not inclined to allow its users to consume all the network resource without prejudice. That is not to say cable needs to manage our customers networks but instead it needs to build architectures to allow our customers portals to manage the content delivery within their own networks.

This paper will detail the technology delta that is required to optimize the IPTV solution for Commercial, Enterprise and Campus environments across the following technologies:

- IPTV Session Resource Management (SRM) through manifest manipulation and other mechanisms
- Network Content Control per network & sub-network
- Licensing and Content Control within customer premise
- Support of SD, HD and 4K video at there respective rates and resolutions
- Empowering the customer to manage and optimize delivery of content by network
- Necessary Client Telemetry to support these advanced capabilities

IPTV as a Primary Service

Video Delivery and QOS/QOE

The historical lessons still hold true. What is the most important part of the video? The audio… Even in the days of analog, people will watch a degraded video image if the audio stream was still discernable. Once the audio stream degrades to a point where it cannot be understood the user will discontinue watching. This basic premise of video delivery has not change since television service was launched. With the adoption IPTV, it still remains true. Video must be delivered with a Quality of Service (QOS) and Quality of Experience (QOE) for the consumers to utilize the service. In the current world of competing technologies and customers to maintain and/or gain eyeballs and market share, the QOE/QOS of video delivery is tantamount to the success of the market.

Commercial Solutions based on IPTV/CDN architectures, as a primary service means the customers are directly paying for the service. Every month, when they pay their bill, they evaluate the subscription value and make decision on service renewal. Commercial IPTV is not an additional offering, a second screen, or a nice to have or is a service that works on some of devices within the premise. Legacy cable set the standard regarding service levels as it is “always on”. Primary is a daunting service level to attain is a significant shift for IPTV/CDN video delivery.

Legacy Cable has both the benefit and bane of being a wholly owned and maintained infrastructure. The integrated and highly coupled headend, hubsite, HFC to certified Customer Premise Equipment (Set-Top-Boxes) was precisely designed to manage QOS/QOE of video delivery. In a sense, by being highly coupled it is simpler to operate. IPTV by its very nature, is less tightly coupled, less centralized, more interconnect and has it own unchallenged benefits but also it own intrinsic challenges. There is a balance between the two and the lessons learned can be applied.

Buffering (latency), discontinuities, jittering, network glitches, where the errors occurs or why the errors occurs, the complexity of delivery, networks, software stacks, encryption, DRM, upgrades are all not the customer’s concern. Simply stated, primary equals “Always On”.

Devices – Consumer Premise Equipment (CPE) and Customer Owned Device (COD)

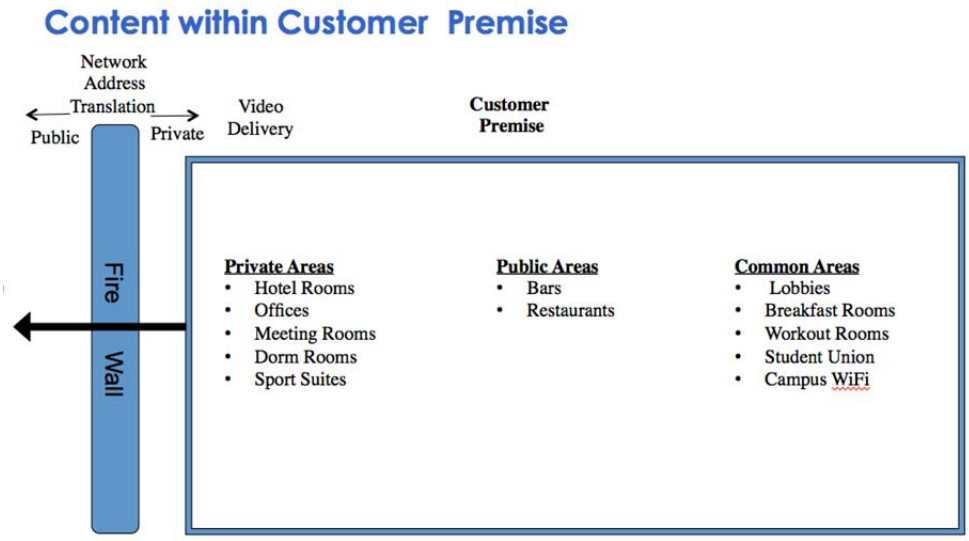
There are two basic classes of devices. Historically cable operators provide all digital decrypt and viewing devices. CPE’s such at Set-Top-Boxes (STBs), Set-Back-Boxes (SBBs) and Digital Tuning Adapters (DTAs). However, in IPTV and Commercial Video the preference is viewing on the PCs/Macs, tablets, Roku devices and other COD devices and the exception would be cable provided CPEs.

Trusted Devices:
In many cases, it is just not practical to require user to login to watch TV. A Trusted Device, is a streaming device that once initial authentication with login and password has occurred, they become "Trusted". These Trusted Devices will automatically sign on and receive the appropriate programming without requiring manual logging into the system as long as their Public, Private and MAC Address remain consistent. At a practical level it is necessary to have Trusted Devices for Public Spaces and Common Areas viewing that may utilize PCs/Macs and Roku like devices for streaming.

Content Within Premise

A key concept within Commercial Video is, Content within Premise. Historically, content programming was to the resolution of a customer address. The address, determined the content that be seen within that customer premise. That is to say, all the devices within a household are provisioned to receive the same content. The content offering may vary based on the CPE variations and generations of hardware deployed within that premise, whether that is analog, MPEG-2, MPEG-4, DTAs with their various video capabilities, but for the most part content is provisioned to the address. Even in most IPTV solutions today, the CODs are validated against the cable modem and content provisioned on the availability and capability of the client viewing device to that address.

However, in commercial instances, the address does not provide enough resolution to determine the viewable content. Content is king and the programmers have many rules regarding how and where content can be viewed. Different content is available in different area and at different rates.



The primary areas of viewing are:

- Public Area – Bar & Restaurants
- Common Areas – Lobby, Breakfast Area, Workout Room, Student Union, Campus Wi-Fi
- Private Areas – Offices, Meeting Rooms, Hotel Rooms, Dorm Rooms

Examples of this are:

- Premiums (HBO, Showtime, etc.) cannot be viewed in Public Areas or Common Area
- Sports Packages & News Package are tailored for Bars and Restaurants
- Music Choice Channels sold at a premise level – all outlets are allowed to view the content

As users move within the premise, connecting to various parts of the network, the content that they are allowed to view will vary.

Additionally many Commercial Customers are "bulk" customers. Meaning that, all viewing outlets may get a base package of content and although it be limited in certain areas there still upsell opportunities. But the architectures should be with the option to allow the customer to be able to upsell and extend their basic lineup with additional services. For example, a college dorm may get basic content package but the student individually may want to add a premium service to it.

Customer Premise Equipment – Customer Owned Devices

Separating Billing and Provisioning

Traditionally, most cable solutions combine both billing and provisioning into a package based approach where both entitlements and the content are tightly coupled. That is to say, the billing system effectively controls both what content the customer is allowed to view and the decryption keys to view to the content. In this approach, the residential billing systems can be highly restrictive regarding and less than an ideal mechanism to addressing the unique rules in Commercial Video environments.

Two common ways to manage and enforce content protection requirements:

1. Channel or tuning access is controlled via the tunable lineup that allows the STBs the ability to tune to the program stream. If a channel is not in the lineup it cannot be accessed.
2. Content streams are encrypted prior to distribution and the decryption keys are sent via a separate communication path authenticated devices.

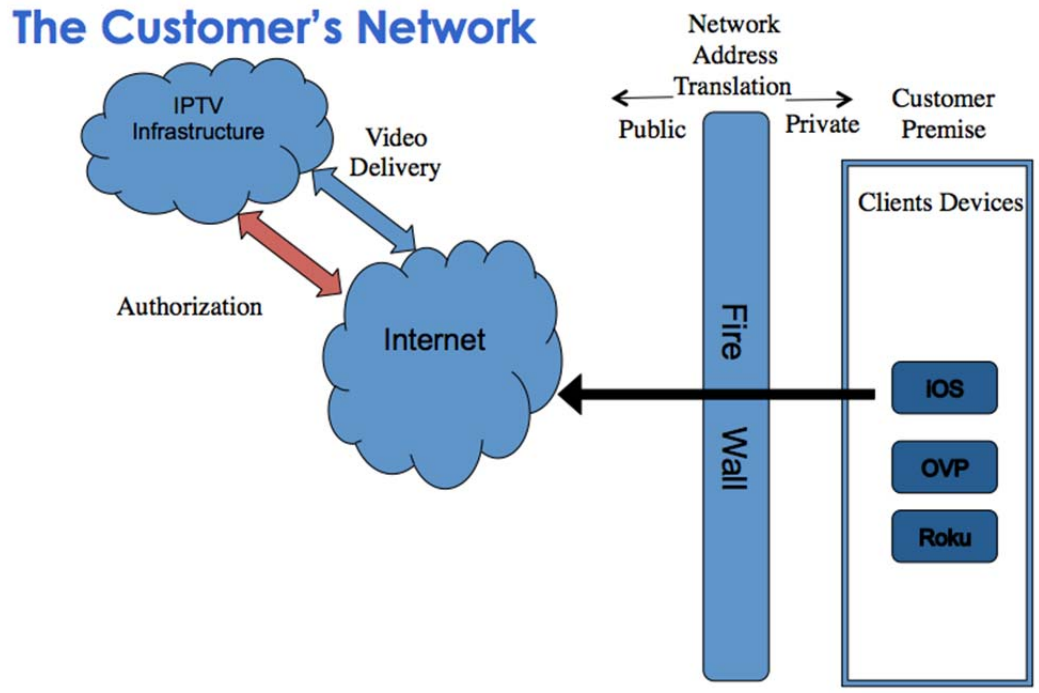
In IPTV the two basic content protection mechanisms are in play but in an IPTV specific context. Content line-ups are controlled by a list of URLs and the client requires a decryption key from a third source to decrypt the encrypted content.

There is significant benefit in separating out the billing from the provisioning. That is to say, to separate out the tunable lineup from the decryption for devices already authenticated on the network. This allows for the commercial premise to be simply "bulk" provisioned and then the channel listing is further refined based on location within that premise by the people who are closer to the deployment.. There are successful commercial architectures today with residential OCAP STB's that utilize bulk provisioning the STBs with the decryption keys and then controlling access through the channel lineup. This has the mechanism supports the need to customize content within the premise and yet securely deliver content.

An IPTV control plane should easily incorporate the separation and flexibility between the billing system and provisioning system and further extend its intelligence of location within premise through network awareness that cannot be done today on the common bus of the 75 Ohm-to-ground that cable is today.

Customer Network Topologies:

Requiring the commercial or business class customers to significantly change their network so that the IPTV service can be launched is only creates a barrier to entry to sell and deploy an IPTV solution. The strategic goal is to build a solution that will mesh and meld into the existing customer's network while providing the operational tools.



Most commercial customers' network topologies consist of a few public IP addresses and a many private IP addresses utilizing the conventionally ranges:

- 10.X.X.X
- 172.16.X.X
- 192.168.X.X

Network Address Translation (NAT) and IP Masquerading provides the mechanism to bridge between the Customer's Private Address space and the Public Internets address space seamlessly. A single Public class A IP Address can server millions of Private IP Addresses. There are unique network identifiers that can be tracked and utilized for a control plane, public IP address, private IP address and the physical MAC Address of the client device. While some networks may be comprised of a series of hierarchical NAT'd networks re-using same private address space more than once, for simplicity sake this paper takes this approach of there unique address space and access points of subtending NAT'd sub-networks would be managed by their parent private address.

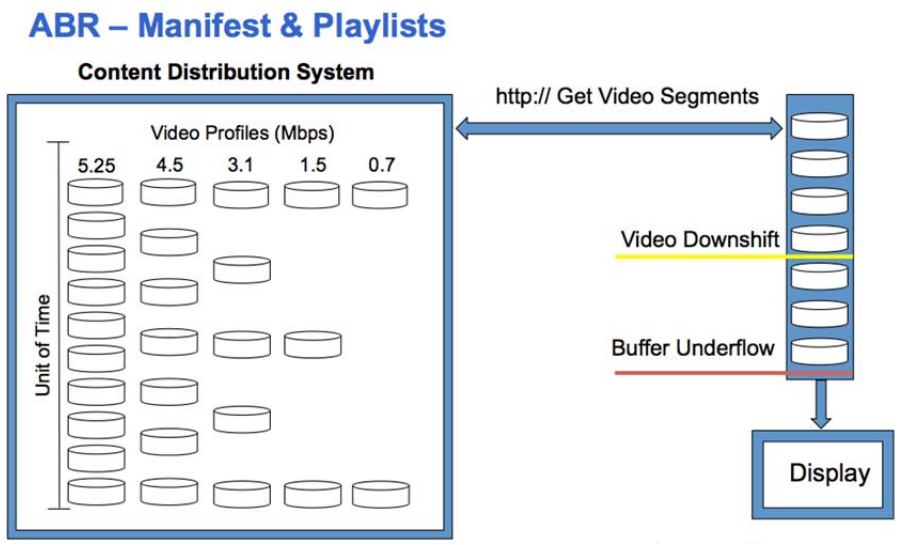
Adaptive Bite Rate Content

The cornerstone of most IPTV/CDN solutions is the Adaptive Bit Rate (ABR) video delivery mechanism.

A single piece of content is encoded into multiple unique transport streams (video encode rates and resolutions) it is then parsed into segments in preparation for delivery via HTTP streaming. Relevant to this paper, the Manifest File describes the video rates and the playlist of those segments. On playback the client can shift between various profiles and video rates as defined within the manifest file. Today ABR content has been focused on SD and HD resolutions but Ultra High Definition (UHD) 4K video is in the not so distant future. Commercial environments are primed be early adopters.

Example of Adaptive Bit Rates:

Live Manifest File	VOD Manifest File
1. 0.7 Mbps	1. 0.7 Mbps
2. 1.5 Mbps	2. 1 Mbps
3. 3.1 Mbps	3. 1.5 Mbps
4. 4.5 Mbps	4. 2.5 Mbps
5. 5.25 Mbps	5. 3.1 Mbps
	6. 3.5 Mbps
	7. 4 Mbps
	8. 4.5 Mbps
	9. 4.85 Mbps
	10. 5.25 Mbps



IPTV Everywhere Is Just That - Designed To Go Everywhere

The optimization of the HTTP and HTTPS protocols for video to seamlessly transverse almost any network topology is the very paradigm that makes managing video within a customer's premise complicated.

At the protocol layer, IPTV streaming, utilizing HTTP/HTTPS on ports 80 and 443 respectively, was developed to blend into the existing network traffic and to seamlessly flow through NAT'd environments traffic. Furthermore, by employing HTTP/HTTPS for streaming of video there is the benefit of circumventing firewall rules. Video traffic looks like any other traffic. For the most part, firewalls cannot simply discern traffic types within the data streams utilizing HTTP/HTTPS protocols. If the video traffic were relegated to a specific IP port(s) it would be easier to identify, manipulate, limit and control but that is not the case.

The fact that video looks like any other traffic from the network perspective necessitates the need place the intelligence, control and monitoring in an IPTV video control plane.

Session Resource Management - Client Side Control, Chaos or Compromise?

The majority of linear "live" TV and for VOD IPTV/CDN content delivered today is based on unicast delivery of content for individual sessions. This is not unlike how classic Video On Demand and Switched Digital Video (VOD/SDV) are transported today. In both cases, the clients initiate the connection to the video stream and stream "profile"

selection is done at that time of session start. They may seem to be similar however the "intelligence" regarding QOS/QOE lies in different network components.

IPTV solutions rely on the client to determine the QOS/QOE based on network telemetry of the client-side requests for individual video segments, buffer consumption rate and underflow of buffers to downshift their stream selection to the video streams identified in their "playlist" or manifest file. At its most basic level all the clients are attempting to stream at the maximum video rate and are affectively competing with each other for network resources.

Classic cable delivery of VOD/SDV relies on a video control plane or Session Resource Manager (SRM) that is cognitive of the video distribution end-to-en and maps out the resources, reserves the capacity and initiates the connection to the stream to ensure QOS/QOE.

The IPTV analog to cable's classic SRM architecture is the manifest manipulator. The manifest manipulator enables the system to define the playlist of video segments, the content of the segment and the available video transport stream in terms of rates and resolution.

There are two basic modes that Manifest Manipulators operate in for session based unicast stream delivery:

1. Static Manifest Manipulation (SMM) – The per user per session manifest is created at the start of the session with all the define playlist and profiles
2. Dynamic Manifest Manipulation (DMM) – The manifest is manipulated during the session and changes to the playlist in real-time allowing for adaption based on the real time freed

While the architecture acknowledges both mechanisms and the benefits of DMM, for the sake of simplicity the base solution is envisioned utilizing the SMM. Implementing DMM is just a natural extension of the solution.

So, can an commercial IPTV solution be created that takes the best of lessons learned from classic and integrate into an affective solution that can address the needs of the commercial market as a primary service? Can we monetize the solution and reduce operation and support costs?

In classic VOD/SDV architectures the initial connection and effectively the QOS is manage through the SRM. In IPTV CDN architectures, the manifest manipulator can affectively be utilize their ability to set the initial bitrate and to also limit or expand the bitrates that are available by editing the playlist of segments (manifest). This can be done at session establishment or at dynamically at during the session.

Deployable Architectural Solutions

Most customers' private networks can be visualized as a branch and tree where the root of tree is the base IP address and the subtending branches are sub-networks off the main address, a basic hierarchy of a core switch and subtending edges switches or wireless routers. Typically, the edge switches/routers are configured to provide a specific range of IP Addresses to the client when signing onto the network via Dynamic Host Configuration Protocol (DHCP). Each edges switch or router provides IP address by a given range or bounded by a netmask.

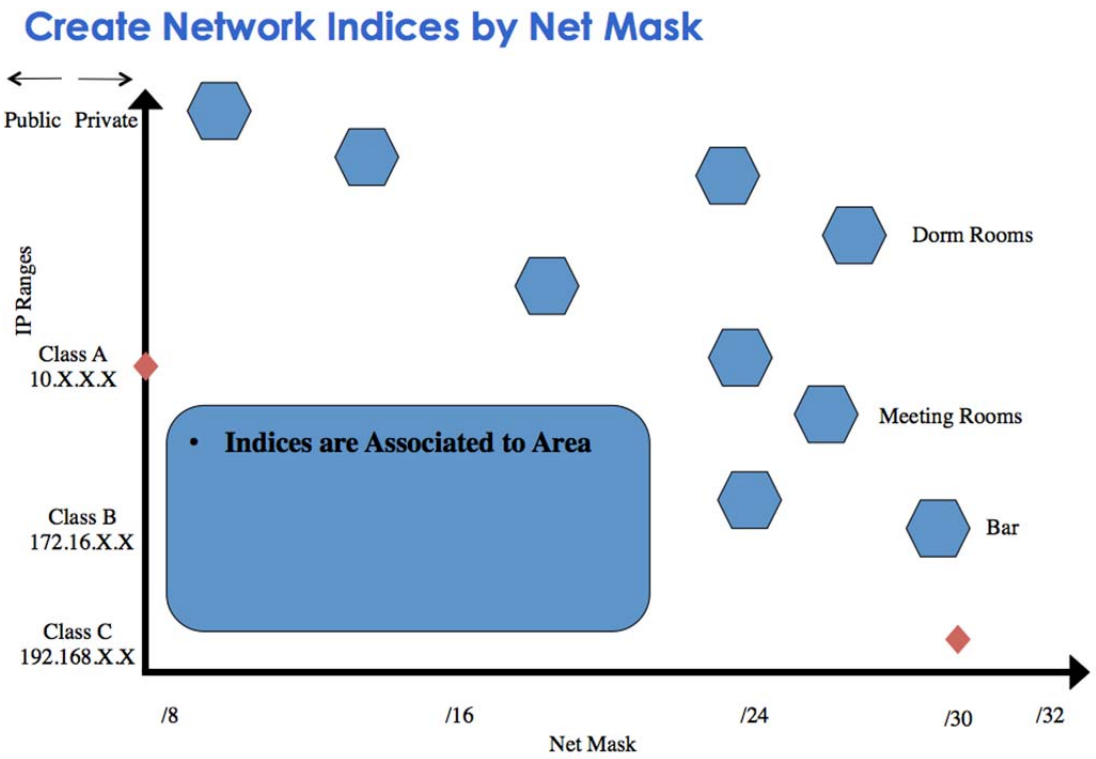
Marrying The Organic Nature Of Networks To The Video Delivery

Due to the very nature customer's private network and the way IP Address may be assigned to clients, the solution architecture needs to be flexible and organic. In other words, the control plane should not have to have intimate knowledge of the customer's network but should provide framework to overlay a control plane. The customer should be configuring the Content Control Plane as the network is being used by the users for content consumption.

This can be accomplished without too much complexity, the IPTV client really only needs to send a few key data points into the control system to provide significant functionality.

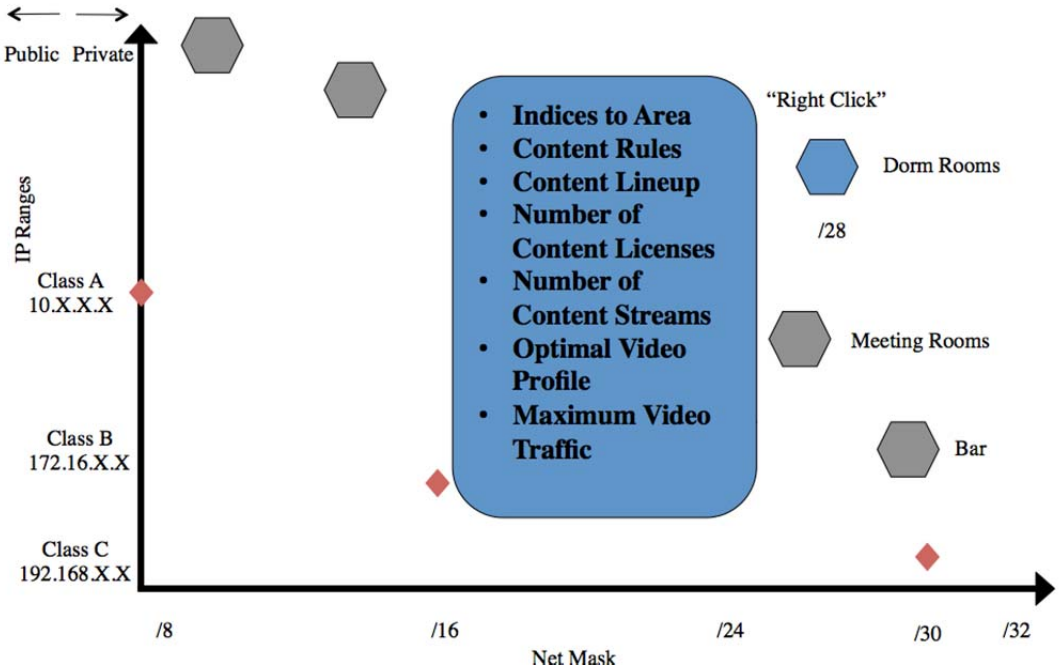
MAC Address - Unique physical identifier of the viewing device of the network interface
Private Address – The IP address given to the COD or CPE device typically through DHCP
Public Address – The customer's Internet public address
Username/ Password - Additionally, the user will have to provide a unique login and password to authenticate onto the control system either directly or through existing OAuth authentication methodologies.

The key concept is to capture the network triplet of MAC, private and public addresses and place them into a database. Once in the database, these devices can be displayed and correlated by network and subnet utilizing subnet mask to correlate and group devices together. By correlating devices to a IP netmask it allows for the association and correlation of devices within a network to a given set of address ranges large or small to create content control indices. For instance, a subnet mask /30 (255.255.255.252) allow for 2 hosts and subnet mask of /26 (255.255.255.192) allows for 62 hosts.



Using the IP subnet mask mechanism to associate hosts into a group of addresses allows for the creation of content control indices within a population of addresses. At each content control indices, the system can then manage and apply content and quality profiles to a group of IPTV clients that sign into this subnet of the network.

Prescribe Control and Content Attributes to Indices



Key attributes for describing Content Control Indices

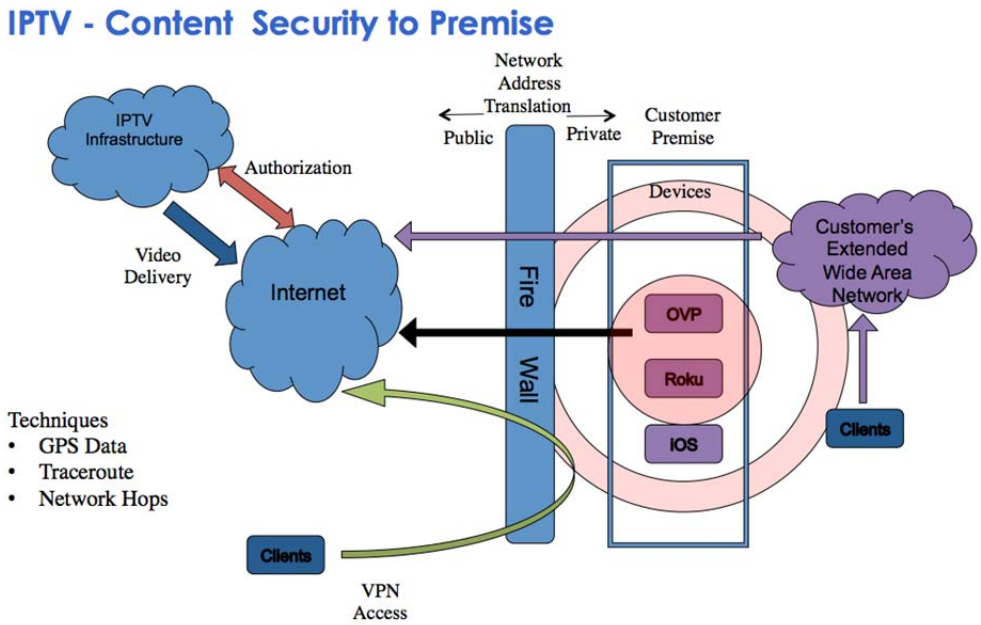
- **Aggregation of IPTV Clients** - Grouping of devices based on subnet of Private IP Address Ranges
- **Content Rules** - Common set of rules to be applied to devices signing on from this range
- **Content Line-up** – The content that is allowed to be viewed at this part of the network
- **Number of Content Licenses** subscribed to this network – The number of simultaneous users
- **Number of Content Streams** - The number of simultaneous streams
- **Optimal Video Profile** – Defining in directly to the manifest manipulation engine to control the video rate to be streamed
- **Maximum Video Traffic** - The total amount of video traffic allow regardless of the number of sessions
- **Aggregate Users to a Profile** – In a unicast model, aggregate users watching the same content to the same video profile (possibly lowest common denominator) to reduce sending of same content but at different rates This could be configured to work at a threshold level
- **Video Performance Telemetry**– Buffer under-run (green, yellow, red) if the network segment cannot keep up with the delivery of video then client buffer under runs will occur and downshifting will occur to a lower bit rate if possible or else the video will become blocky or stutter

Note, the number of license/users may oversubscribe a network subnet but the stream limitation will ensure the maximum amount of bandwidth consumed. Restating this, there can be more users licensed on a content control indices that there is bandwidth to service all those customers. The system should be able to manage and control the concurrency for the number of users and streams.

Securing Content to Premise

The network triplet of MAC, private and public address can be used to help validate identify the location of the customer within the network. Typically, "cable modem" check to ensure the user is behind the public address is used today but additional telemetry data like having client perform and provide the response of a traceroute between itself and the CDN can also provide insight to the customer's internal network and mapping into send to the database. These data points can even help pinpoint the user's location and determine whether the user has tried to access the service off-premise via a Virtual Private Network (VPN).

There are two extremely complex use cases for the Content Control Plane to try an compensate to ensure content is limited to the premise. This first is when a user establishes a VPN into the network and second is the when a user is on the customer's extended network. In both cases the users appear as if they are on the native client on the network. Utilizing custom client code, unique capabilities of some of the client devices and the knowledge of the network.

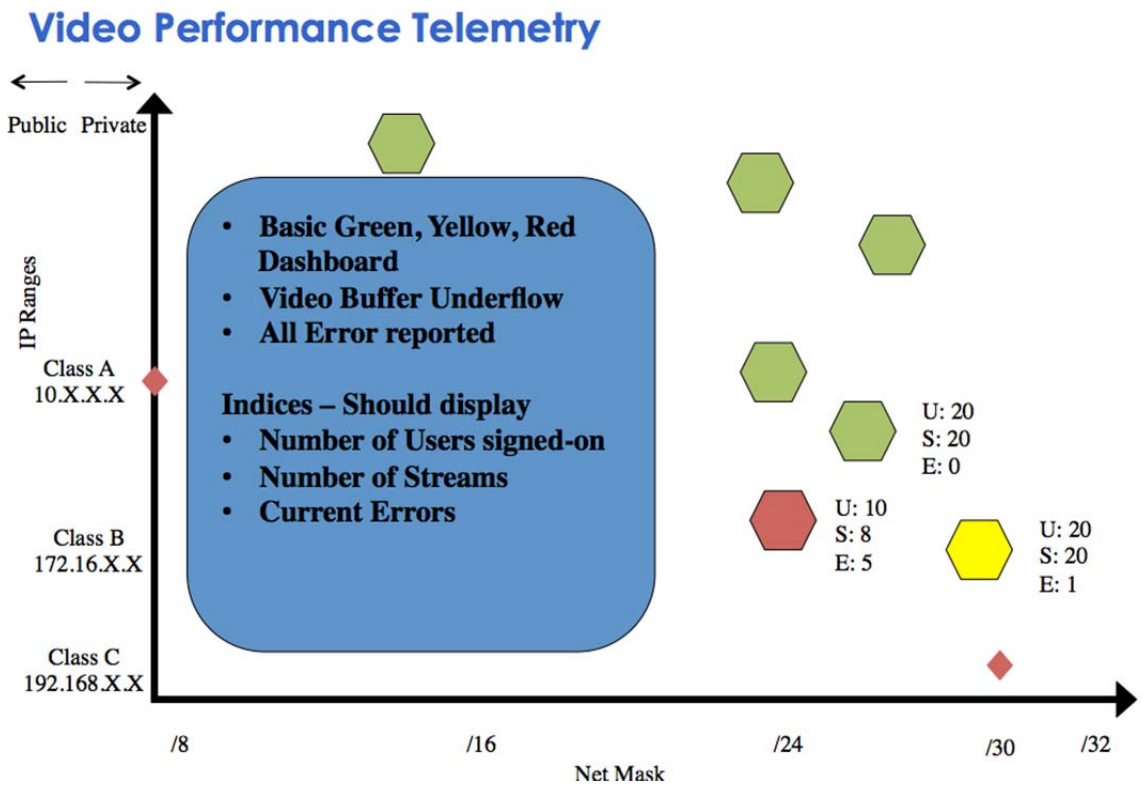


There also is more complex data to gather, but can add additional capabilities to content control plane. The data is:

- GPS - If the device supports this capability then the exact location can be mapped
- Traceroute – A list of IP addresses that client passed through to connect to the control plane
- Hop Count – The number of network hops that the client takes to reach an address

Customer Managed Control Plane

So, who knows the customer's network better than the customer? This is rhetorical as the answer is self-evident. The network administrator becomes a key person in the overall lifecycle solution from initial RFPs, sales, implementation and operations. Video consumes a lot of bandwidth and they are aware of the delicate nature of their network. They are the ones that will first ask the question, how much bandwidth will video consume, how do I limit it, how do I know that is working across the network. The network administrator manages their own network and its capacity and capabilities better than the MSO without that intimate knowledge can manage.

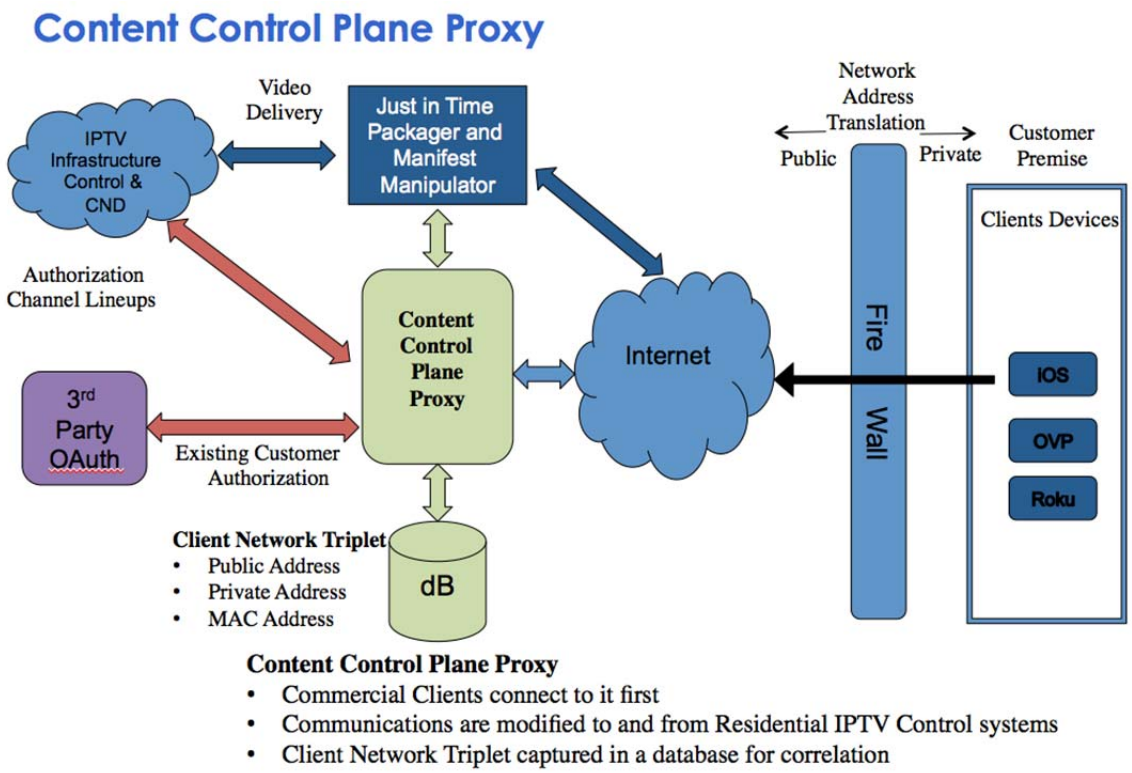


This approach is not trying to development another network management system or element management system but is trying to create a content and video QOS plane within any given network where the customer can manage their own:

- Concurrent consumption of content within the network
- Number of users consuming content
- Utilization of network resources for video delivery
- Number of users connected at the various content indices and throughout their network
- QOS/QOE feedback as to whether the video is being delivered a the selected profile

Commercial Control Plane – How Does It Fit Within The Existing IPTV Ecosystems?

The preferred approach is to minimize the technology delta required to integrate the Commercial Control Plane into the existing IPTV/CDN infrastructure. One approach is to place the Commercial Control Plane affectively as a proxy server between the client and the existing IPTV Control Plane. Instead of having clients initially connect to the residential IPTV system, the commercial client would connect to the Commercial Control Plane first that would act as a proxy server. The Commercial Control Plane, intercepts these communications, appends or tailors them and then forwards them onto the residential system.



Authentication
It is by this same method, subtending authorization systems could be utilized to authentic the user against their existing OAuth mechanisms and then authenticates them against the core residential systems. This ensures the user is authenticated against the commercial entities' authentication system and the core residential system.

Content Manipulation
On the return calls from the residential system back to the client to can also be modified in this manner. For example, the residential system would return the channel lineup and the Commercial Control Plane would substitute the appropriate lineup for that user, public, private and MAC address and ensure the proper content is limited within the premise. For VOD content, the same basic principle would be applied but the control would against the uniqueness of the product, provider pairing or rating.

Stream Manipulation
The Commercial Control Plane will also need to have hooks into the manifest manipulator to support the optimization of video profile for that particular network segment within the customer premise. The client would request the stream and the telemetry data of that request would be sent to the Commercial Control Plane which would then interact with the manifest manipulator to include the optimal profiles in the manifest. The client would then read the manifest and start streaming.

Content Delivery within the Premise Unicast/Multicast and CDN Nodes

Typically, most CDNs operate in a unicast model from the output of the CDN to the viewing device. That is to say, each stream regardless whether is linear or On-Demand, is unique when delivered between the CDN and the viewing device.

In large deployment, the scaling numbers of CDN unicast streams can be very high requiring a large interconnect bandwidth between CDN and customer's network and customer's premise and the bandwidth within the premise. The bandwidth requirement scales linearly and can be simply calculated by taking the stream rate and multiplying it by the number of concurrent streams.

For very large deployment like a university solution, a CDN caching node can be place at the customer premise. In this manner, only the unique content is streamed between the core CDN and the customer's premise, however within the premise all stream are unicast. Affectively, on the interconnected bandwidth streams are "de-duplicated" and the caching node replicates them into unicast streams.

Having the Caching Node output IP multicast streams may seem to be an easy simple approach but operating multicast networks can tax a customer's network switch infrastructure. In the traditional ABR architecture, there are multiple instances each video at different video profiles, Digital Right Management (DRM) and rates so the CDN caching node may be have to multicast out a significant amount traffic on then rely on customer's network to delivery of that multicast traffic. The problem is transformed one set of problems to another as each and is not completely solved. That being said, having the Content Control Plane limit the profiles and rates to offer the lowest common denominator stream may mitigate the impact on the customer's network

These approaches may work fine for linear but for VOD there is little recourse, as it will always be unicast delivered by its very nature of being session based On Demand.

Content & Capacity - Subsidizing Video Delivery Impacts

Traditional RF/QAM based commercial video is offered as a single service, the network and capacity and video content are tightly coupled. Thousands of video streams both linear and non-linear are available on this single piece of coaxial cable.. For instance, the raw capacity of a coax is around 4.6 Gbps for a 120 channels system of raw digital QAM capacity without FEC (38.8Mbps x 120 QAMs), a significant payload.

With IPTV solutions, the bandwidth does not have to be tightly coupled together with the delivery video services The high speed data (HSD) service can be purchased separately from the video content.

While all video services, regardless of how they are delivered are burdened by a significant cost-of-goods form of programming fees at varying rates and percentages, HSD is not services are not directly burdened by the cost of content of flowing across the connections. This affords HSD services to have higher margins associated to them.

Restating this, the Content License Fees and Capacity is bundled together on a coaxial based solution but it is not directly the necessarily the case with IPTV.

Basic equation:
Cable Margin = video rate charged – cost of goods

IPTV Margin = HSD rate + (video rate – cost of goods)

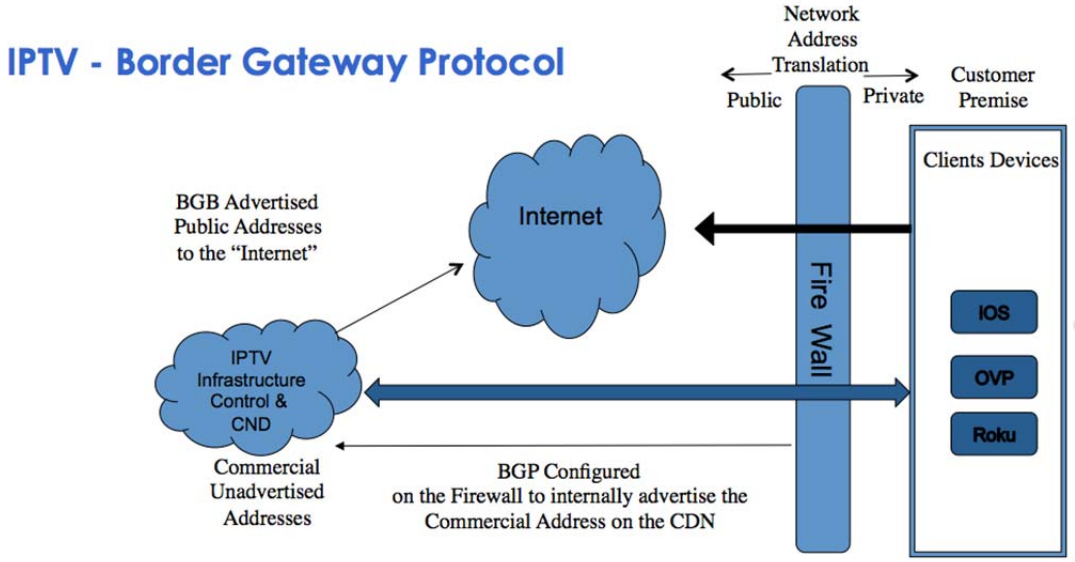
In the IPTV paradigm, it is important not to devalue the HSD margins by having it subsidize video delivery by burdening it with the content costs of goods. At the same time, there engineering/architectural tradeoffs need and the impacts of trying to limit the connections only to the CDN across the interconnect between the CDN and the client.

If a dedicated connection required for the delivery of the IPTV then can the traffic be limited just to the streaming video? There is not a straightforward solution, but a solution that should be explored.

Breaking the problem into two important concepts, navigation versus streaming. Since majority of the traffic is the streaming of content the problem of limiting the access solving the streaming side problem is key. But the same time some IPTV clients will need to have access to the Internet to navigate.

The IPTV/CDN infrastructure is typically deployed in the Public Domain of the Internet so limiting it complicated. Border Gateway Protocol (BGP) is a networking mechanism is used to advertise the connections between peer networks or in case not to advertise at all except a few specific connections.

To control the pathway to the CDN, it is envisioned that the CDN would have IP addresses that are advertised through BGP to the Internet on the whole and then set of commercial IP addresses that are not advertised. In any case, the CDN IP Addresses are public but are selectively advertised.



On the customer premise, there would a demarcation switch exclusively for IPTV. This switch would not advertise its connection to the Internet on the whole to the customer's network via BGP but would only advertise the routes to the Commercial IP Address on the CDN at the Networking Reachability Layer.

Clients would navigate via other Internet connections to access the Video Control Plane and the IPTV navigation sites until they are receive URLs to stream content. Within the customer's demarcation switch the routes to the Commercial IP addresses on the CDN would be advertised internally to the customer's network. The client's within the customer premise would be able resolve the streaming URLs and the demarcation switch would route the request to the CDN. The practicality of this type of solution has not been fully vetted and may only apply to the large-scale enterprise customer level.

Deployment Use Cases:

The College Campus Use Case

A College Campus may represent the all the opportunities and all the complexities of an IPTV Bulk Video in a single customer instance. The college campus will have a mix of residential halls, public lobbies, lecture halls, stadiums, campus areas and administration offices with both wired and wireless networks. The "closed" environment of a campus solves many of the "chicken-and-the-egg" 4K dependency is on acquiring, distributing and decoding the content where there is a tremendous amount of that is "User Generated" on campus including sporting events, faculty lectures and campus stations. So, campuses could be viable IPTV 4K early adopters.

Wired versus Wireless Networks - On the whole, the network administrator may want to discriminate between video services on the two basic networks

Dorm Rooms – Offering a basic bulk video channel line-up and the opportunity to upsell the individual user into additional premium tiers of service.

Campus WiFi – All public areas across campus WiFi network the optimum video profile most likely set to the lowest bitrate to provide public viewing lineup but minimize network load.

Lecture Halls - The network administrator may want to entirely inhibit content on the WiFi network within in these buildings. At the lecterns, the highest possible video profile including 4K video and customize the line-up that includes 4K video to the lecture room screens all across a wired network.

Campus Bar & Restaurant – The upcoming 2016 Olympics will be produced and broadcasted in 4K. Will bars and restaurants afford the expense of replacing their HD TVs with UHD4K sets and having 4K content package designs for this event?

Stadiums – Live capture of sporting events, different camera angles.

Residential Home Use Case

So this technology could still be important within the context of residential service. For example, a user may want to customize and limit the channel line to only a few kids channels and to the lowest bitrate so that the kids can watch content without having to set parental control controls or having concerns how my WiFi traffic is going to be consumed by the device.

Conclusion

Launching IPTV services into Commercial Markets Video is viable on both a technology front and business case. The demand for Video there but the preferred medium is shifting. The ideas and concepts presented in these paper, chart a course to take the industry to meet the requirements of commercial market. The solution must take in to account the current state of video and the future state of video when UHD 4K video is the standard. By taking the industry's lessons learned regarding video QOS/QOE, native telemetry and operational support and applying them in the context IPTV and creating a Content Control Plane to serve the IPTV Commercial Market, cable can serve this market better than any other provider. Video is at the core of cable.

Acronyms

ABR	Adaptive Bit Rate
BGP	Border Gateway Protocol
CDN	Content Distribution Network
COD	Customer Owned Devices
CPE	Customer Premise Equipment
DHCP	Dynamic Host Configuration Protocol
DMM	Dynamic Manifest Manipulation
DRM	Digital Rights Management
DTA	Digital Tuning Adapters
GPS	Global Positioning Satellite
HD	High Definition
HFC	Hybrid Fiber Coax
HSD	High Speed Data
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IPTV	Internet Protocol Television
MAC	Media Access Control
MSO	Multiple System Operator
NAT	Network Address Translation
OCAP	Open Cable Application Platform
QAM	Quadrature Amplitude Modulation
QOE	Quality of Experience
QOS	Quality of Service
RF	Radio Frequency
RFP	Request For Proposal
SBB	Set Back Box
SD	Standard Definition
SDV	Switch Digital Video
SMM	Static Manifest Manipulation
SRM	Session Resource Management
STB	Set Top Box
UHD	Ultra High Definition
URL	Universal Record Locator
VOD	Video On Demand
VPN	Virtual Private Network
WiFi	Wireless Network

Biography:

Glen Hardin is presently the Senior Director, Video Systems for Time Warner Cable where he is responsible for Commercial Video Architectures and the One VOD program for both the Classic Cable and IPTV platforms. In his 24 years in the interactive television industry, Mr. Hardin pioneered the development and integration of many of the technologies necessary to bring VOD and Interactive Television to the market. Throughout his career he has worked for several cutting edge technology development companies, including Guestserve Systems, IPC Interactive, Wink Communications, SkyConnect, and nCUBE.

Mr. Hardin received a Bachelor of Science in Electrical Engineering with a minor in Business Administration from the University of Nevada, Reno.