Pioneering IPTV in Cable Networks

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

As cable operators craft IP Video strategies to meet their unique objectives, most would probably agree it is no simple task. From the cloud to the network to the connected home, operators face a multitude of choices for addressing the growing demands of subscribers to access more content on more devices whenever and wherever they want it. With precious few deployments of full-scale IP Video services over cable networks to date, most operators have limited experience to draw on when deciding which technical solutions will best serve their particular needs.

This paper aims to assist operators in selecting the most appropriate DOCSIS network architecture for delivering IP Video services. Using data collected from leading-edge commercial IPTV deployments with Cisco CMTS and Edge QAM solutions, we examine viewership patterns and compare unicast and multicast delivery approaches in terms of the most critical DOCSIS network resources: CMTS capacity and HFC spectrum. We also look ahead at how the Converged Cable Access Platform (CCAP) initiative and advanced connected home solutions simplify operations and provide more flexibility in delivering the complete portfolio of data, voice and video services.

Linear IPTV Viewership

Viewership statistics were collected from three Cisco CMTS's delivering a full suite of IPTV services including Linear IPTV and IP Video on Demand (IPVoD). Table 1 provides the number of IPTV set-top boxes (STBs) served by each CMTS, and the number of viewers of Linear IPTV services based on data samples taken in July, 2013. The samples from CMTS-1 and CMTS-2 were taken during prime time, while the CMTS-3 sample was taken outside prime time. The Linear IPTV viewers includes all IPTV STBs that were receiving a Linear IPTV channel at the time the sample was taken, whether the channel was being viewed by the subscriber or recorded by the STB for post-broadcast viewing. In either case, the network delivered the content to the IPTV STB.

	CMTS-1	CMTS-2	CMTS-3
IPTV STBs	8,459	7,893	4,647
Linear IPTV Viewers	4,503	4,560	3,651

Table 1. Linear IPTV Viewers

According to the data collected from our customers' networks, IPTV viewership on cable networks is similar to Digital Cable viewership. This is to be expected, since subscribers want to access the content of interest to them and don't really care about the underlying service delivery infrastructure. The Linear IPTV services are clearly very popular, with more than half of the IPTV STBs served by each CMTS accessing a Linear IPTV service at the time the samples were taken. Furthermore, as shown in Figure 1, IPTV viewership follows the familiar distribution curve we've seen from Switched Digital Video (SDV) deployments (see [1] and [2]), with the most popular channels forming the "short tail" with tens or even hundreds of viewers per channel at a given time, and the less popular channels forming the "long tail" with just a few (or no) viewers per channel at a given time.

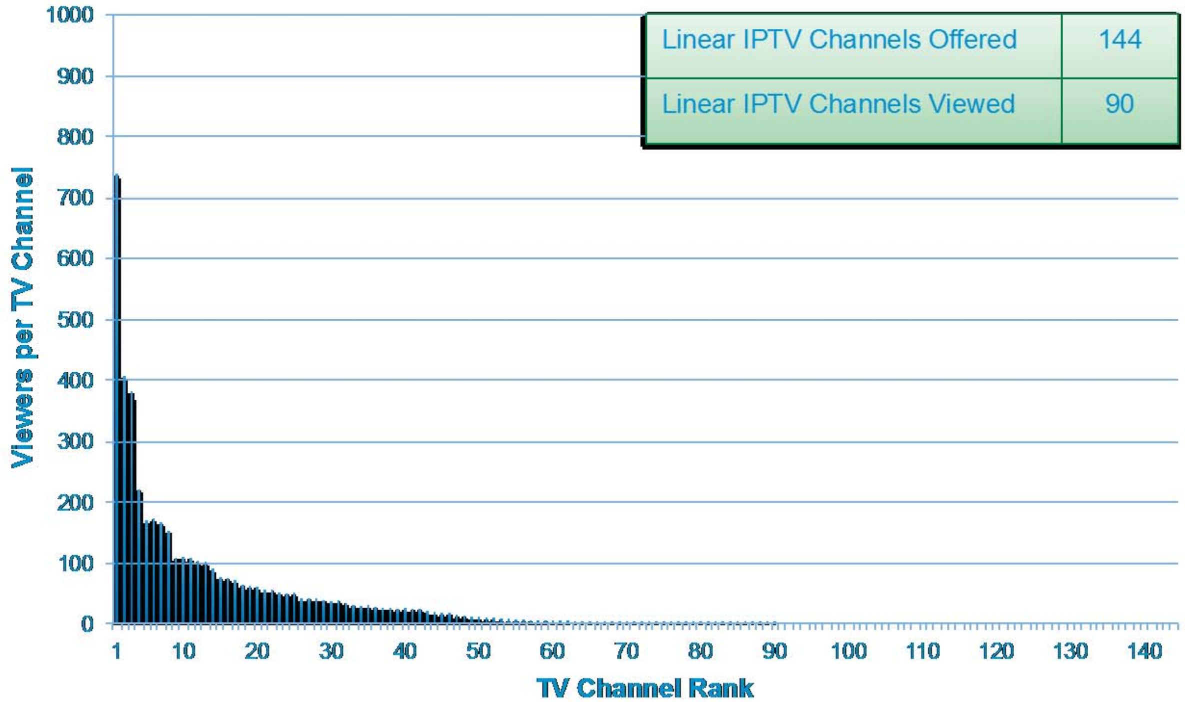

Figure 1. Viewers per TV Channel – CMTS-1

Figure 2 depicts the Linear IPTV viewership on CMTS-2, which delivers the same Linear IPTV channel lineup as CMTS-1, but is located in a different city than CMTS-1. The viewership pattern is very similar to the viewership in CMTS-1, with an even higher number of viewers viewing the top-ranked channel.

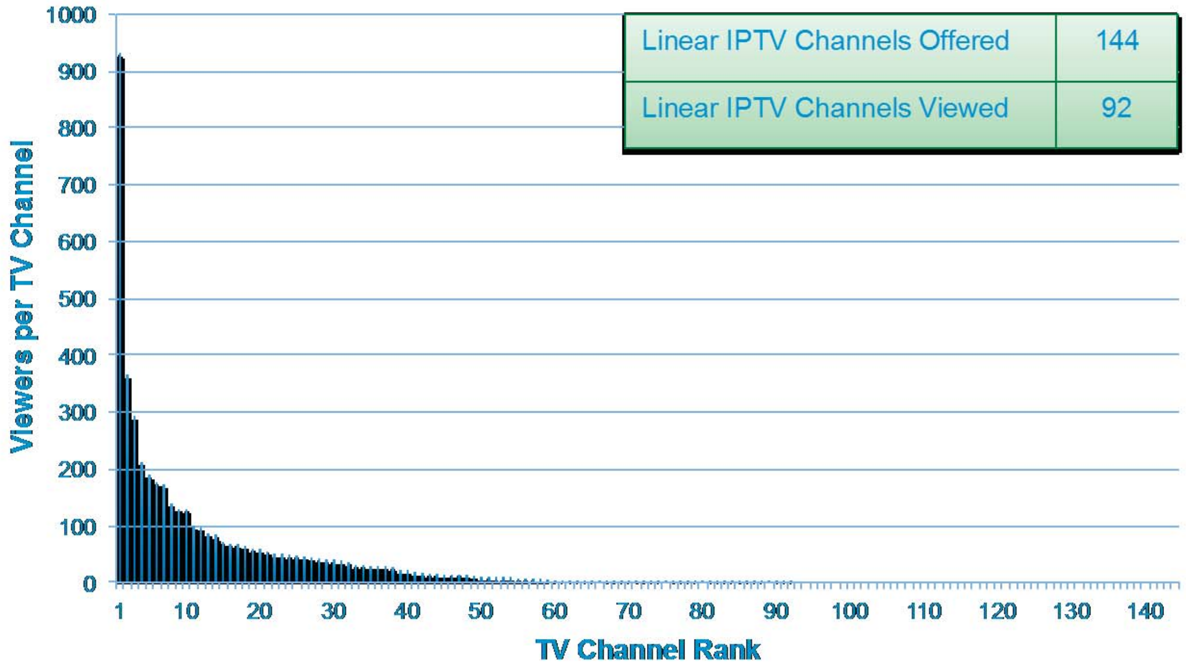

Figure 2. Viewers per TV Channel – CMTS-2

Figure 3 depicts the Linear IPTV viewership on CMTS-3, which delivers an entirely different Linear IPTV channel lineup than CMTS-1 and CMTS-2, and is located in a geographical region with very different demographics. The viewership is more distributed than on CMTS-1 and CMTS-2, which is likely due to the fact that the sample was taken outside of prime time when the most popular programs are not airing. However, the short-tail and long-tail characteristics are still evident.

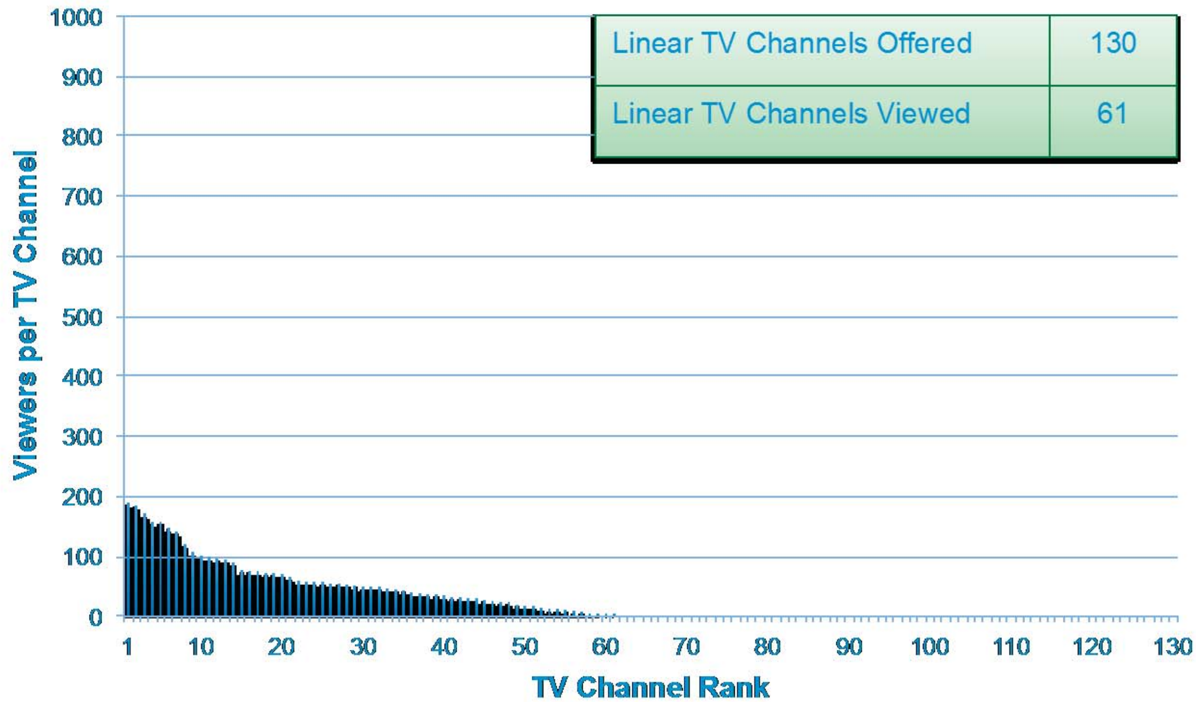

Figure 3. Viewers per TV Channel – CMTS-3

Table 2 provides a breakdown of the total viewers for the most popular TV channels. More than half of the viewers were watching one of the Top 10 channels at the time of the sample. Even though the Top 10 channels are not exactly the same for CMTS-1 and CMTS-2, the viewership distribution is nearly identical. The short-tail viewership of CMTS-3 exhibits a similar concurrency pattern, though not as pronounced in the Top 10 as CMTS-1 and CMTS-2. This common characteristic of viewership suggests that multicast would be a very efficient approach for delivering the Linear IPTV services in each case, and will be examined further later in this paper.

TV Channels	Percentage of Total Viewers		
	CMTS-1	CMTS-2	CMTS-3
Top 10	58%	60%	41%
Top 20	76%	77%	63%
Top 30	87%	87%	78%
Top 40	93%	94%	90%
Top 50	97%	97%	97%

Table 2. Viewership of Most Popular TV Channels

Viewership by Service Group

The data shown in Figures 1-3 is the total Linear IPTV viewers for each CMTS. In cable networks, the most limited resource is often HFC spectrum, which is allocated to the Service Groups served by the CMTS. An IPTV Service Group (SG) is defined as a group of IPTV STBs that share HFC spectrum and CMTS resources. Table 3 provides the number of IPTV SGs per CMTS and the average number of IPTV STBs per SG.

	CMTS-1	CMTS-2	CMTS-3
IPTV STBs	8,459	7,893	4,647
IPTV Service Groups	39	21	8
IPTV STBs per SG (average)	217	376	581

Table 3. IPTV Service Group Data

The viewership per SG is a critically important factor when deploying IPTV in cable networks because it determines the HFC spectrum required for the Linear IPTV services. Figures 4-6 provide the breakdown of Linear IPTV viewership per SG for each CMTS. As shown in Figure 4, more than half of the 39 SGs served by CMTS-1 had at least 100 viewers at the sample time, with a maximum of 265 viewers and minimum of 53 viewers per SG.

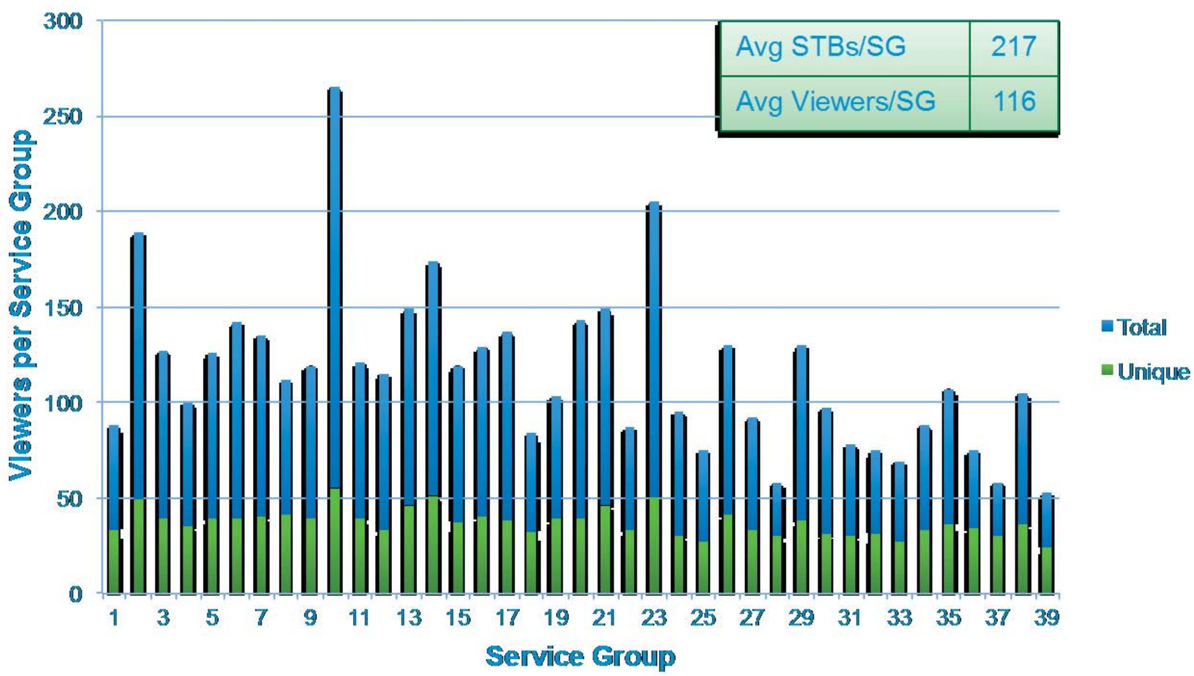

Figure 4. Viewers per Service Group – CMTS-1

Another important factor when deploying IPTV in cable networks is the number of unique Linear IPTV channels viewed within each SG. This reflects the per-channel concurrency within each SG, which is indicative of the efficiency of multicast delivery. As shown in

Figure 4, the average number of unique Linear IPTV channels viewed within each SG served by CMTS-1 was 37, with a minimum of 24 and maximum of 55. This data supports the prior observation that virtually all viewership was accounted for by the Top 50 channels (see Table 2).

There were nearly twice as many viewers per SG served by CMTS-2 than CMTS-1, yet the average number of unique Linear IPTV channels viewed per SG on CMTS-2 was only about 25% greater than on CMTS-1 (see Figure 5). Thus the per-channel concurrency was higher on CMTS-2 than on CMTS-1, which suggests that multicast delivery would be even more efficient on CMTS-2.

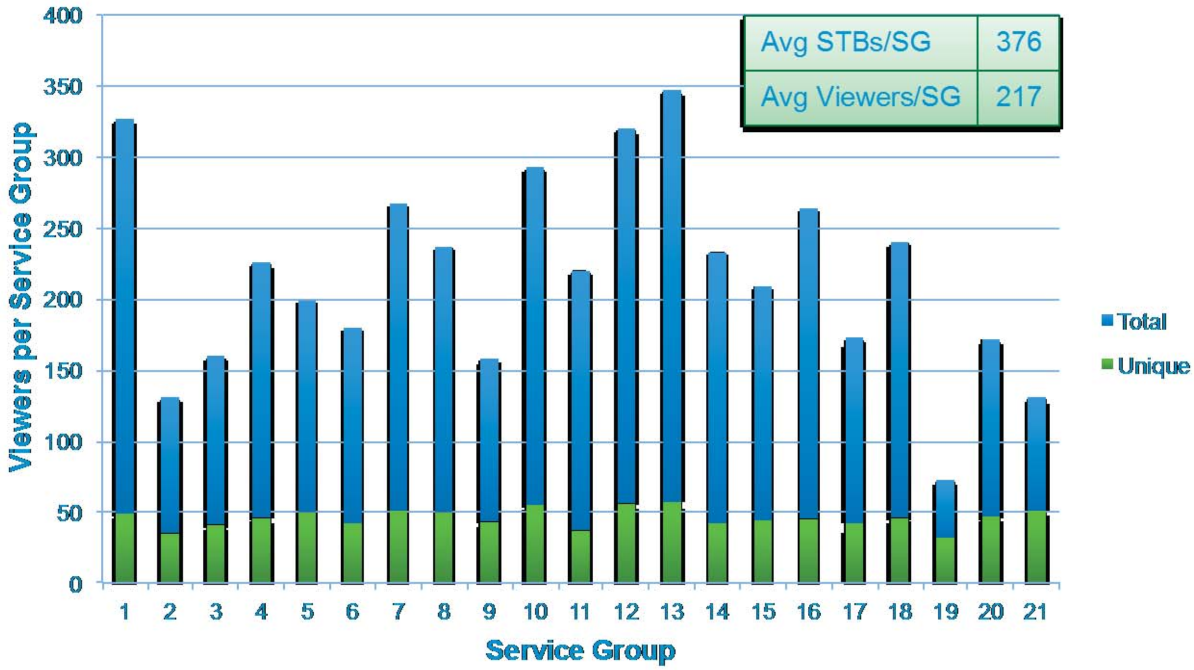

Figure 5. Viewers per Service Group – CMTS-2

Although CMTS-3 only serves eight SGs, the average SG has nearly triple the number of IPTV STBs compared to CMTS-1. As observed with CMTS-2, larger SGs generally exhibit higher per-channel concurrency, and this is clearly evident on CMTS-3. As shown in Figure 6, CMTS-3 served nearly four times more Linear IPTV viewers per SG with only 50% more Linear IPTV streams (on average) compared to CMTS-1. And the maximum number of unique Linear IPTV channels viewed per SG was roughly equivalent to that of both CMTS-1 and CMTS-2. The higher per-channel concurrency suggests that multicast delivery would be even more efficient on CMTS-3, which we will examine further later in this paper.

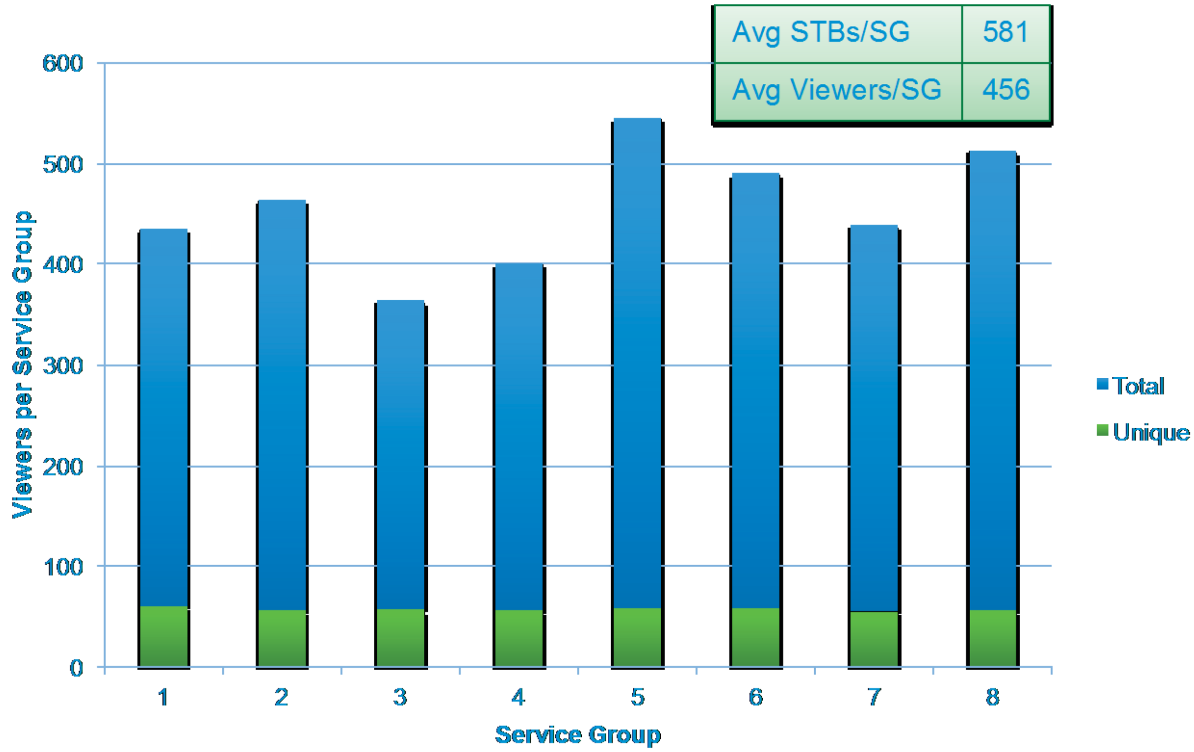

Figure 6. Viewers per Service Group – CMTS-3

Linear IPTV Delivery in Cable Networks

Cable operators can deliver IPTV services in much the same way as they deliver Digital Cable services today: using broadcast, switched, or unicast delivery. The broadcast and switched approaches use IP multicast in a one-to-many network architecture. Unicast delivery is used for interactive services like on-demand and cloud DVR, but can also be used for Linear IPTV in a one-to-one network architecture. These three approaches are compared in the following sections.

Unicast Delivery

Unicast delivery is the most demanding on the network. With each subscriber receiving a unique stream, the network must scale based on the numbers of subscribers accessing the service at any given time. Also, unicast delivery can be inefficient for Linear IPTV, since the same Linear IPTV stream may be delivered multiple times within the same SG. Figure 7 illustrates the capacity required on the IPTV Server, CMTS and HFC Network to deliver the Linear IPTV services in the CMTS-1 scenario. This assumes the Linear IPTV services are encoded using constant bitrate (CBR) encoding with an encode rate of 8 Mbps per stream, and each CMTS DS channel and 6-MHz HFC channel has a capacity of 35 Mbps. Recall there were 4,503 Linear IPTV viewers served by CMTS-1 at the sample time, so that is the number of streams that must be output by the IPTV Server and delivered to the CMTS. A total of 1,029 DS channels would be required on CMTS-1, distributed amongst the 39 SGs. While an average of 26 CMTS DS and HFC channels would be required per SG, the largest

SG would require 61 DS and HFC channels. Keeping in mind that this capacity is required just for the Linear IPTV service, and does not include High-Speed Data (HSD), Voice over IP (VoIP), or IPVoD services, unicast delivery of Linear IPTV is not practical in this scenario.

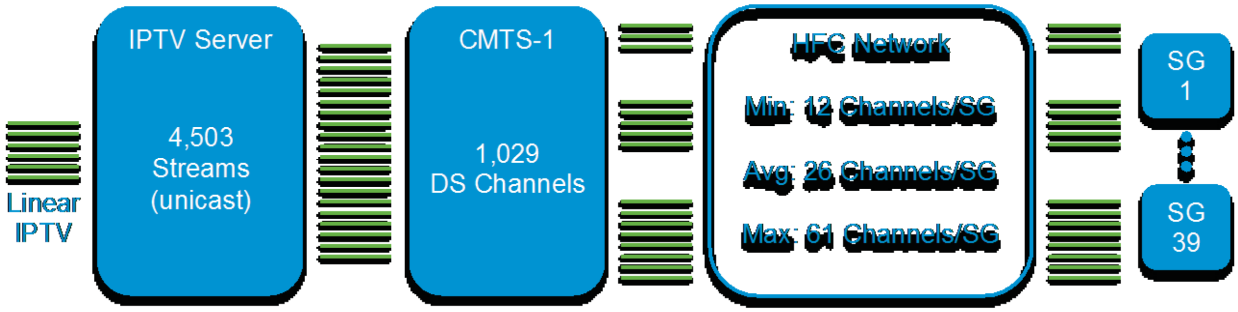

Figure 7. Unicast Delivery of Linear IPTV – CMTS-1

All-Switched Delivery

By contrast, Figure 8 depicts the capacity required to deliver the Linear IPTV services in the CMTS-1 scenario using the All-Switched architecture. In this case, a Linear IPTV channel is delivered only to those SGs in which one or more subscribers has requested that particular channel, and multicast delivery is used such that one instance of each Linear IPTV channel can be shared by all viewers within the SG. This results in the most efficient use of HFC spectrum, a very desirable attribute in cable networks with limited available spectrum. This approach also significantly reduces the capacity required on the IPTV Server, the CMTS, and the IP network interconnecting them.

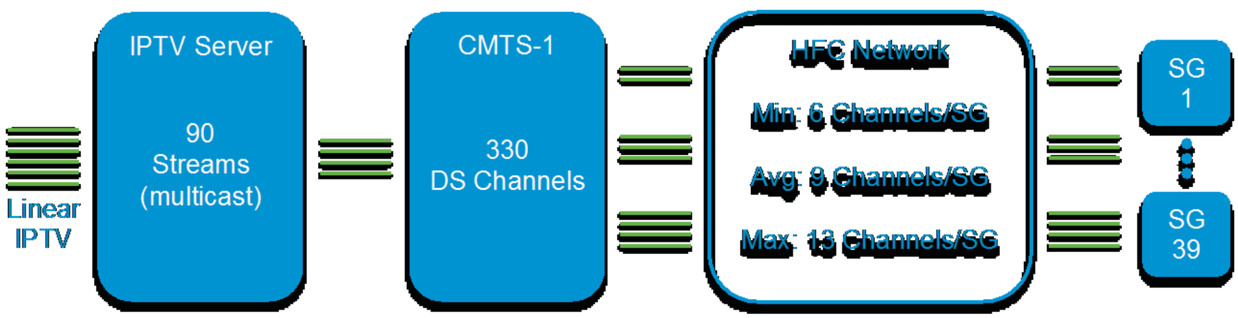

Figure 8. All-Switched Delivery of Linear IPTV – CMTS-1

The efficiency of the All-Switched approach can be described as "multicast gain" and calculated as the number of viewers in a SG divided by the number of unique Linear IPTV channels being viewed in that SG. Multicast gain is the average number of viewers per Linear IPTV channel (i.e. per-channel concurrency) within a SG, and is a measure of the efficiency of multicast delivery compared to unicast delivery. For example, a multicast gain of 3 indicates that the Unicast approach requires 3X the number of streams (and thus CMTS DS and HFC channels) as the All-Switched approach. Figure 9 summarizes the multicast gain for each CMTS scenario (assuming 8 Mbps per Linear IPTV stream and 35 Mbps per CMTS DS and HFC channel). While the multicast gain varies by SG, the Unicast approach would require from 3X to 8X on average of the IPTV Server, CMTS DS and HFC channel capacity of the All-Switched approach for the given scenarios.

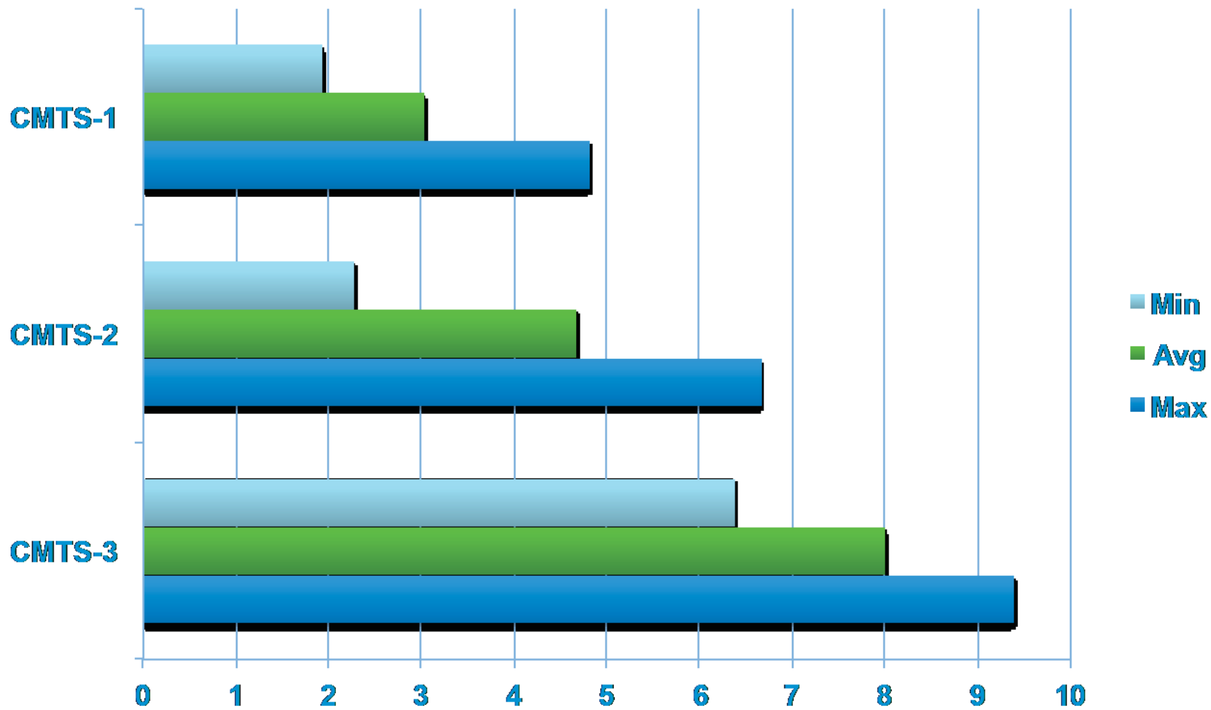

Figure 9. Multicast Gain per Service Group

According to our analysis, the IPTV deployments achieved somewhat higher multicast gains than was observed in SDV deployments in 2008 [1]. This difference could be attributable to a variety of factors, including the smaller channel lineup offered in the IPTV deployments, the programming available when the data was collected, differences in subscriber demographics, and even the data collection/analysis methodology. In any case, our analysis indicates that the Linear TV services offered by the operators continue to draw a large viewing audience, and multicast delivery is still a very effective tool for delivering Linear IPTV services in cable networks.

Despite the multicast gains of the All-Switched approach, there are instances in which a single viewer is viewing a given Linear IPTV stream within a SG. Table 4 provides the number of Linear IPTV streams with only a single viewer in a SG for each CMTS at the time of the sample. For example, there were 639 streams being viewed by a single viewer within a SG on CMTS-1, which would imply that there is no multicast gain for these specific streams. However, when we look at viewership per CMTS, we can see that only 15 Linear IPTV channels were being viewed by a single viewer on CMTS-1. Thus the All-Switched approach provides significant savings in terms of IPTV Server streaming capacity, CMTS WAN capacity, and the IP network interconnecting the IPTV Server and the CMTS, even for Linear IPTV channels viewed by a single viewer within a SG.

	CMTS-1	CMTS-2	CMTS-3
Total Linear IPTV Viewers per CMTS	4,503	4,560	3,651
Single Viewers in a Service Group	639	314	48
TV Channels with Single Viewer per CMTS	15	16	0

Table 4. Single Viewers

All-Broadcast Delivery

Another approach for delivering Linear IPTV services in cable networks is to multicast the entire channel lineup to all SGs at all times regardless of viewership, similar to broadcast delivery of Analog and Digital Cable services. In this case, the CMTS outputs a single instance of each Linear IPTV channel, which is then electrically split and fed to each SG. The capacity requirements for delivering the Linear IPTV services in the CMTS-1 scenario using the All-Broadcast approach are depicted in Figure 10.

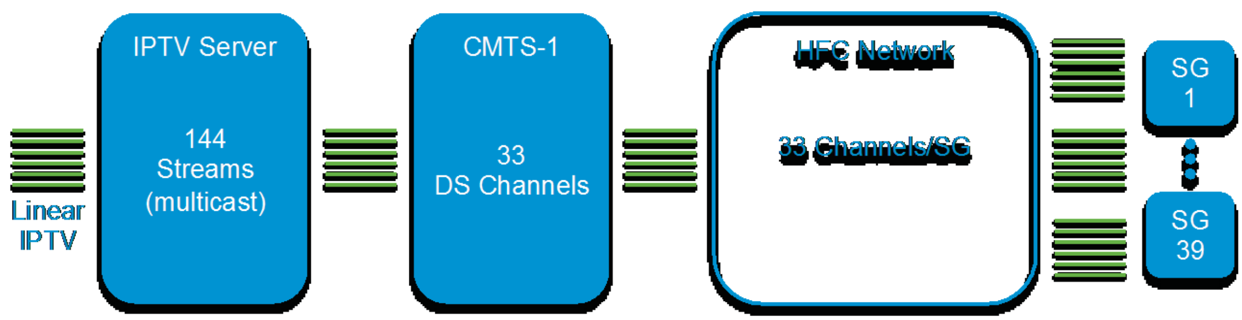

Figure 10. All-Broadcast Delivery of Linear IPTV – CMTS-1

The major benefit of the All-Broadcast approach is the savings in CMTS DS channel capacity. In the CMTS-1 scenario, the CMTS DS capacity can be reduced by 90% using the All-Broadcast approach compared to the All-Switched approach. However, the HFC spectrum requirements are significantly higher, with 33 channels per SG compared to a maximum of 13 channels with the All-Switched approach. One reason the broadcast approach requires so much more HFC spectrum is the fact that 54 of the 144 Linear IPTV channels were not being viewed at all on CMTS-1 at the sample time. Therefore, delivering those 54 channels would be a waste of spectrum.

Another challenge with the All-Broadcast approach is that one or more receive channels in the cable modem must be dedicated to the Linear IPTV service. In the All-Broadcast architecture, Linear IPTV channels are delivered via “secondary” DOCSIS 3.0 channels (either as single- or multi-channel DS bonding groups), and each cable modem tunes to a secondary DS bonding group as well as its primary DS bonding group simultaneously. Dedicating one or more receive channels to the Linear IPTV service (or to any service for that matter) reduces the number of receive channels available for all other services. For example, this could limit the top speed of the HSD service that the operator can offer. As discussed later in this paper, new DOCSIS 3.0 gateways with more receive channels will help to overcome this challenge.

Broadcast+Switched Delivery

The final option for delivering Linear IPTV services in cable networks is to combine the broadcast and switched techniques. In this case, the most popular content is broadcast to all SGs all the time, while the long-tail content is switched to each SG based on viewership. This approach achieves similar HFC spectrum efficiency as the All-Switched approach while significantly reducing the CMTS DS capacity required.

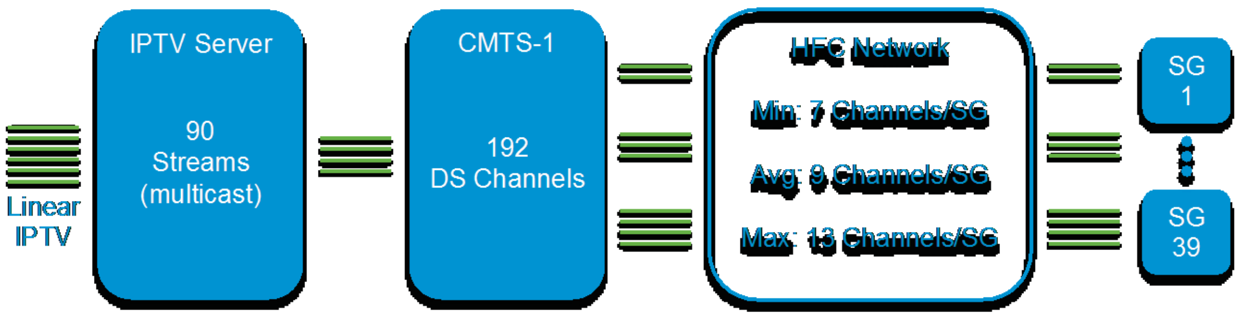

Figure 11. Broadcast+Switched Delivery of Linear IPTV – CMTS-1

As shown in Figure 11, using the Broadcast+Switched approach would save 138 CMTS DS channels (42%) compared to All-Switched delivery in the CMTS-1 scenario. If each broadcast TV channel were viewed by at least one viewer within each SG, then the Broadcast+Switched approach would require the same HFC spectrum as the All-Switched approach. Otherwise, the Broadcast+Switched approach would require more HFC spectrum (based on how many broadcast TV channels were not being viewed within each SG).

Comparison of Linear IPTV Delivery Approaches

The pros and cons of each of the above Linear IPTV delivery options are summarized in Table 5.

	Pros	Cons
Unicast	• Alleviates need for multicast throughout IPTV system • Potential for per-user advertising • Traffic engineering based on active viewers, not TV channel popularity	• Requires large amount of HFC spectrum • Highest CMTS capacity and cost • Adds latency to channel change • Can result in blocking
Switched	• Most efficient use of HFC spectrum for Linear IPTV service • Lower CMTS capacity and cost than unicast • Bandwidth sharing with other IP services	• Traffic engineering based on viewership statistics • Can result in blocking
Broadcast	• Nominal CMTS capacity and cost • Independent of viewership – easier to design and maintain • No blocking	• May be inefficient use of HFC spectrum • Requires dedicated receive channel(s) in cable modem for Linear IPTV
Broadcast + Switched	• Efficient use of HFC spectrum • Low CMTS capacity and cost • Bandwidth sharing with other IP services • Popular Linear IPTV channels are "always on"	• Variation in channel popularity may require adjustment of broadcast vs switched channels for optimal efficiency • Requires dedicated receive channel(s) in cable modem for broadcast TV

Table 5. Comparison of Linear IPTV Delivery Approaches

Techniques for More Efficient Linear IPTV Delivery

All of the above calculations for CMTS DS channel capacity and HFC spectrum assume the Linear IPTV services are encoded using CBR encoding with an encode rate of 8 Mbps per stream. Operators can significantly reduce the bandwidth requirements by using Variable Bit Rate (VBR) encoding and leveraging the channel bonding and IP statmuxing capabilities of the CMTS. As described in [3], these techniques can increase the number of Linear IPTV streams that can be carried within a given amount of DS channels by more than 50%.

IPTV Delivery with CCAP

The Converged Cable Access Platform (CCAP) initiative provides several benefits for delivering IPTV services in cable networks. The massive scalability of CCAP solutions, as outlined in the CCAP specification [4], enables cable operators to address the anticipated rapid growth in IPTV services. And converging all IP and Digital Cable services on CCAP solutions enables operators to gracefully migrate to IPTV.

The CCAP specification also describes "QAM replication" as a key feature for supporting all data, voice and video services without requiring SG alignment. For Linear IPTV services, QAM replication can be applied to simplify the broadcast and switched architectures. Figure 12 depicts the Broadcast+Switched architecture without QAM replication, in which case external splitting/combining is used to combine the broadcast TV channels shared by all SGs with the switched TV channels and the HSD, VoIP, IPVoD and Digital Video services that are unique to each SG. Note that the "RF spanning" feature on the CMTS enables DOCSIS DS channels carrying the broadcast TV channels to be shared by all DOCSIS SGs served by the CMTS. With this approach, an RF port is dedicated to the broadcast TV services, thereby requiring N+1 RF ports to serve N SGs.

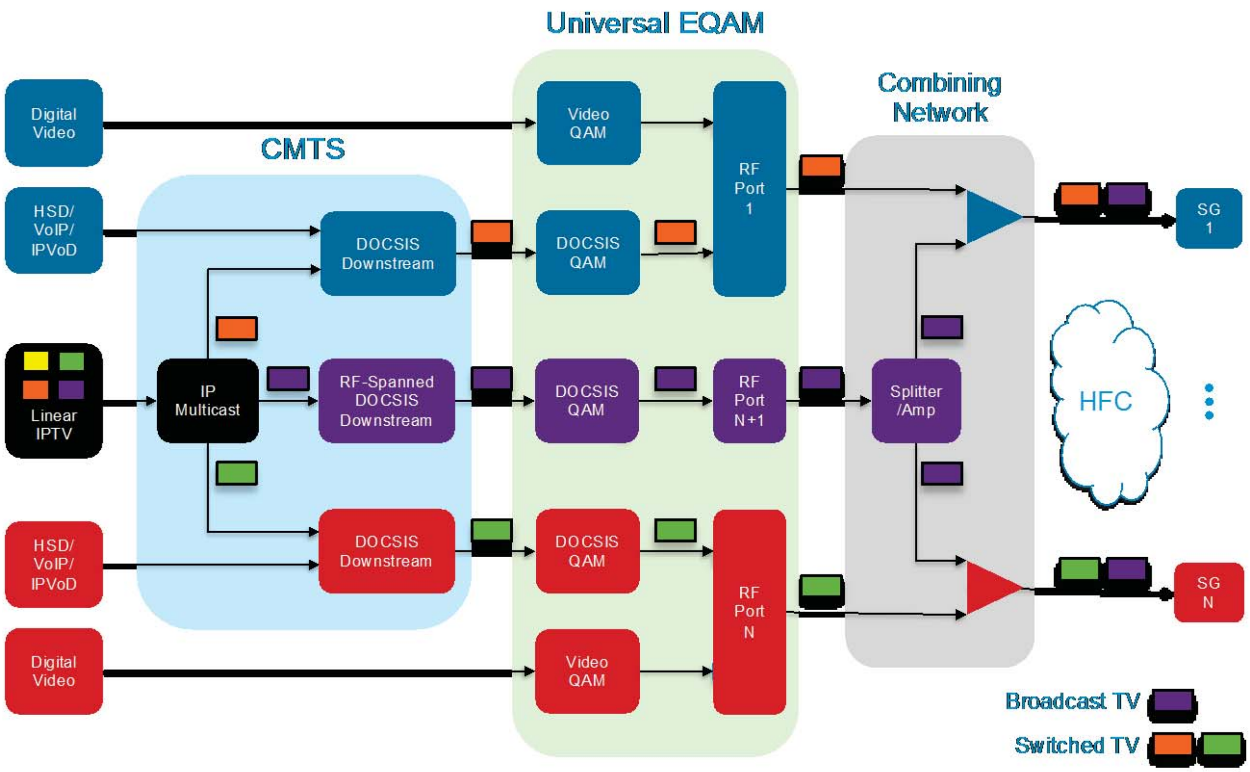

Figure 12. Broadcast+Switched Architecture with External Splitter/Combiner

The benefit of performing QAM replication of the broadcast TV channels within the Universal EQAM component of the CCAP solution is illustrated in Figure 13. The external splitting and combining is no longer required, nor is the N+1 RF port. Instead, the DOCSIS DS channels carrying the broadcast TV channels are replicated and fed to the RF ports supporting each SG. This allows greater utilization of the RF port channel capacity, which lowers equipment costs and reduces rack space and power consumption.

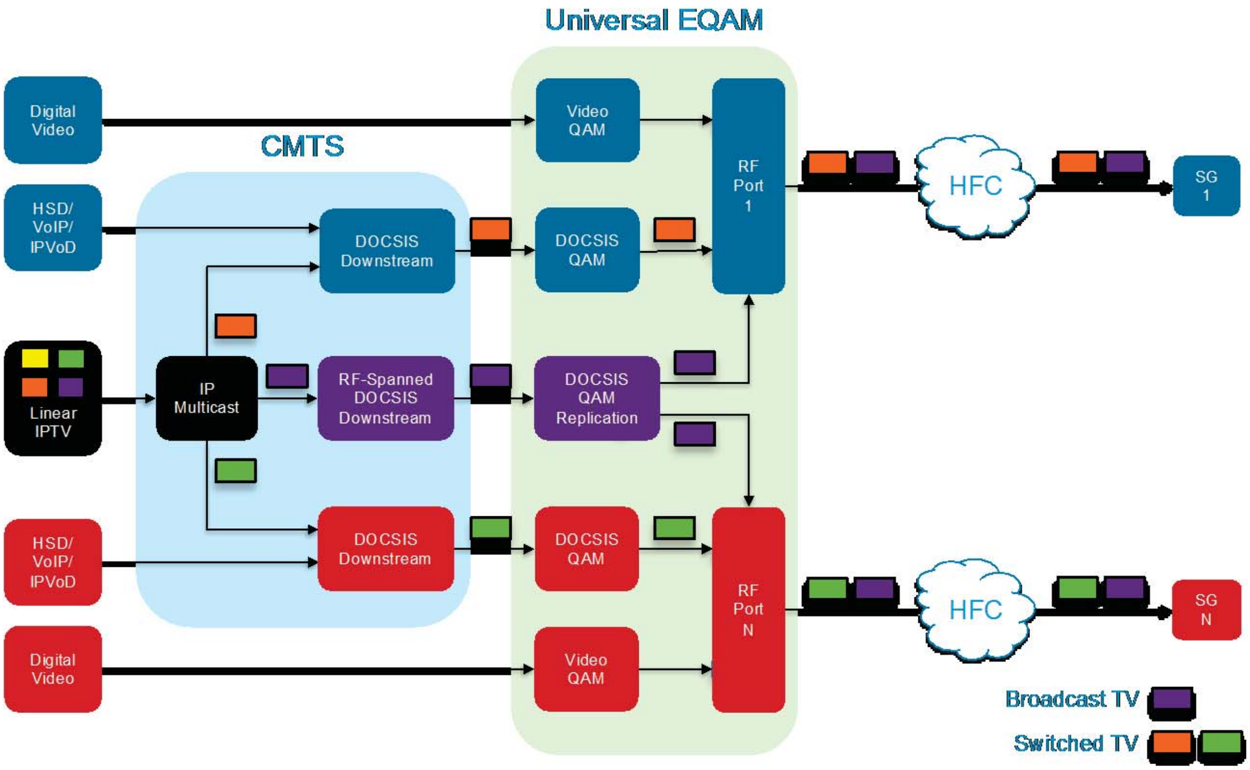

Figure 13. Broadcast+Switched Architecture with QAM Replication

Although not shown in Figures 12-13, the RF spanning and QAM replication features are also applicable to switched TV channels in the event the Linear IPTV SG's are not aligned with the HSD or IPVoD SGs. Operators may choose to maintain large Linear IPTV SGs to maximize their multicast gains, but reduce the size of HSD or IPVoD SGs in order to allocate more bandwidth per subscriber to those services. These features can also be applied to HSD services to allow operators to offer faster speeds without having to dedicate more DS channels to every HSD SG.

Connected Home Solutions for IPTV

Advanced DOCSIS 3.0 Gateway Solutions

To date, IPTV deployments in cable networks have employed 8x4 DOCSIS 3.0 cable modems/gateways, including the three scenarios documented in this paper. Although these modems/gateways all have eight transmit and four receive channels, their configuration varies based on the Linear IPTV delivery approach. For example, a gateway configuration used with the Broadcast+Switched architecture in IPTV deployments today is shown in Figure 14. In this example, the gateway is equipped with dual wideband tuners: one tuner is used to receive up to four DS channels carrying HSD, VoIP, IPVoD and switched IPTV services, while the other tuner is used to receive up to 4 DS channels carrying broadcast IPTV services.

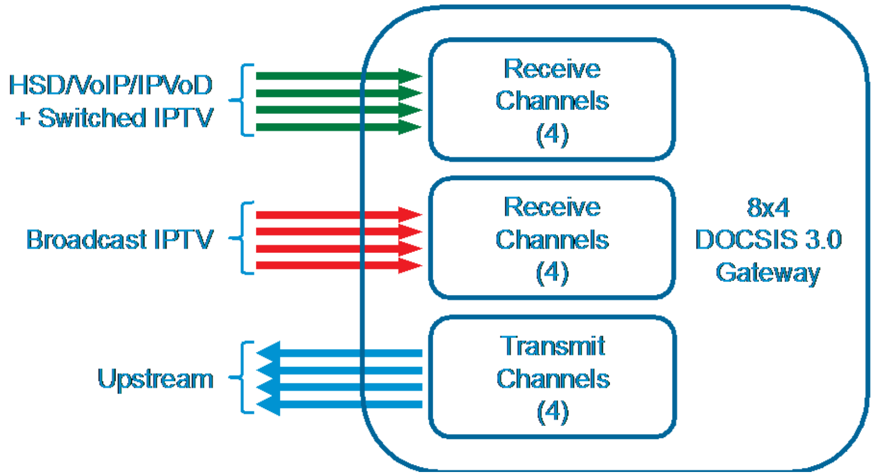

Figure 14. 8x4 Gateway in Broadcast+Switched Architecture

Since one of the tuners in the dual-tuner gateway is dedicated to broadcast IPTV services, the number of receive channels that can be allocated to HSD services is reduced, thereby constraining the top speed of the HSD service. Gateways equipped with a single, full-spectrum wideband tuner offer more flexibility in allocating the receive channels to different services. Figure 15 depicts a single-tuner gateway in the All-Broadcast architecture. In this example, up to seven receive channels are shared by HSD, VoIP, and IPVoD services, while the eighth receive channel is dedicated to Linear IPTV services (which are all broadcast). The CMTS directs the gateway to tune the eighth receive channel to the appropriate DS channel in order to receive the broadcast IPTV channel requested by the subscriber (via the IPTV client). The interaction between the IPTV client, CMTS and modem is accomplished using standard IGMP and DOCSIS 3.0 protocols, with less than 500ms latency from the initial subscriber request to arrival of the multicast stream at the IPTV STB.

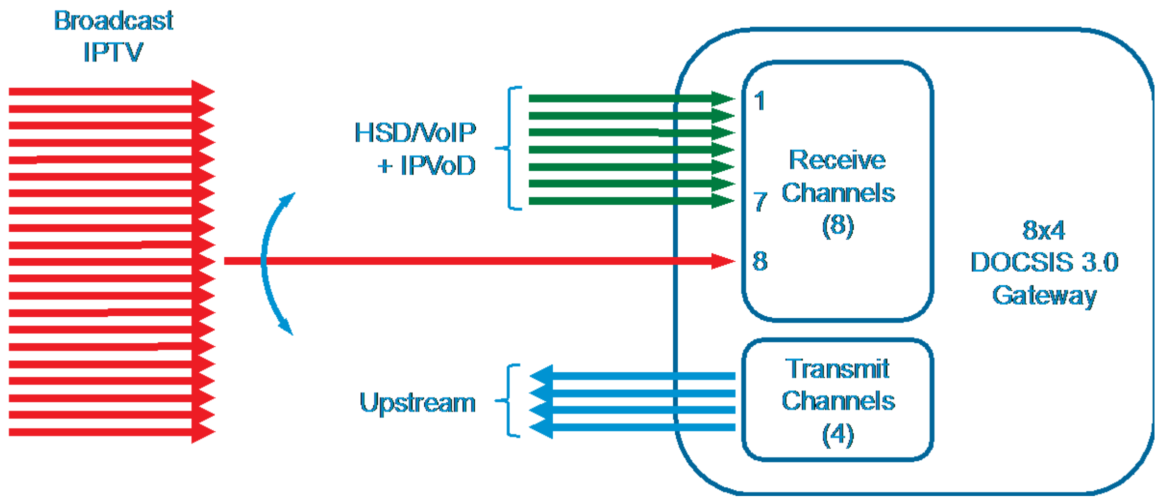

Figure 15. 8x4 Gateway in All-Broadcast Architecture

New DOCSIS 3.0 gateways are now entering the market with 16, 24 or 32 receive channels, and 4 or 8 transmit channels. These advanced gateways provide operators much greater flexibility in delivering a full suite of IP services. For example, operators can deploy 24x8 gateways in the All-Switched architecture with 8 receive channels dedicated to switched IPTV services and the remaining 16 receive channels shared by HSD, VoIP and IPVoD services (see Figure 16). Although the All-Switched architecture enables all services to be delivered over shared DS channels, it also supports using dedicated DS channels to deliver the switched IPTV services. As noted previously, operators may choose to dedicate DS channels for the switched IPTV services so they can maintain large Linear IPTV SGs (and maximize multicast gains) as they reduce the size of the HSD and IPVoD SGs in order to allocate more bandwidth per subscriber for those services. The RF spanning and QAM replication features of the CCAP solution would be employed to deliver switched IPTV services on multiple RF ports simultaneously.

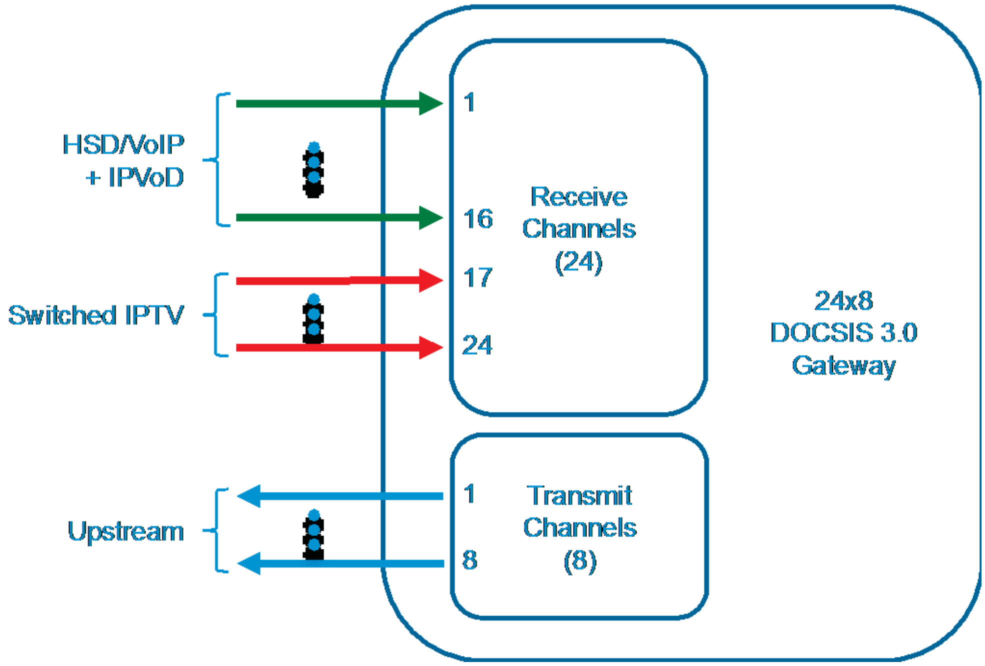

Figure 16. 24x8 Gateway in All-Switched Architecture

Cable operators interested in the All-Broadcast approach could employ 24x8 gateways as shown in Figure 17. Rather than dedicating a single receive channel for broadcast IPTV services (as in Figure 15), multiple channels could be allocated based on the number of simultaneous broadcast IPTV streams required within a home. For example, with four receive channels allocated to broadcast IPTV, the modem could forward at least four unique broadcast IPTV programs to IPTV clients simultaneously. This could include an IPTV DVR STB with the capability to watch/record multiple programs, and/or multiple IPTV STBs within a home being used to view unique broadcast IPTV services.

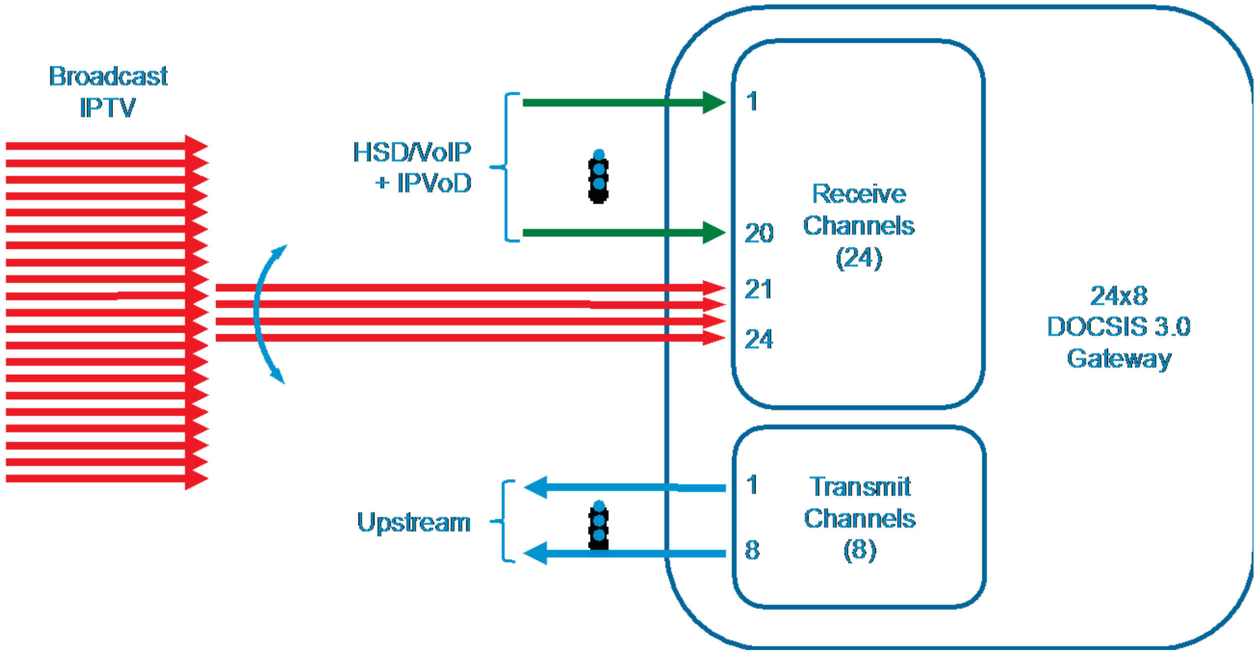

Figure 17. 24x8 Gateway in All-Broadcast Architecture

While this approach requires advanced functionality on the CMTS to manage IGMP-triggered retuning on multiple receive channels simultaneously, it provides a very cost-effective solution for broadcast-centric applications such as analog reclamation with IPTV STBs. And since each gateway would only tune to the individual DS channel(s) carrying the broadcast IPTV service(s) being viewed by IPTV clients behind it, the number of IPTV channels that could be broadcast would only be limited by HFC spectrum availability.

Unified Gateway

The advanced DOCSIS 3.0 gateway capabilities described above are also available in Unified Gateways (UGW), which add capabilities for receiving Digital Cable services delivered via video QAM channels in addition to receiving IP services delivered via DOCSIS channels. Unified Gateways can be used with any of the Linear IPTV delivery approaches described in this paper, and can serve as an effective connected home solution for transitioning to IPTV. Operators can save HFC spectrum with UGWs by eliminating the need to simulcast the Linear TV services in both Digital Broadcast and IPTV formats. Integrated digital video stream processing capabilities enable a UGW to receive Digital Broadcast services over video QAM channels and deliver those services to IPTV clients over the home network.

Figure 18 depicts an example scenario of a 24x8 UGW in which 18 of the 24 receive channels are allocated to receive IP services over DOCSIS 3.0 downstream channels, and the remaining 6 receive channels are allocated to receive Digital Broadcast services over video QAM channels. In this configuration, the UGW can support at least six Digital Broadcast services concurrently, and also support IPVoD and switched IPTV services to complement the Digital Broadcast services. This enables operators to offer enhanced Linear TV and on-demand services via IPTV clients on a variety of IP video devices. As services transition from Digital Broadcast to IPTV, operators can adjust the allocation of receive channels, ultimately leading to all-IP.

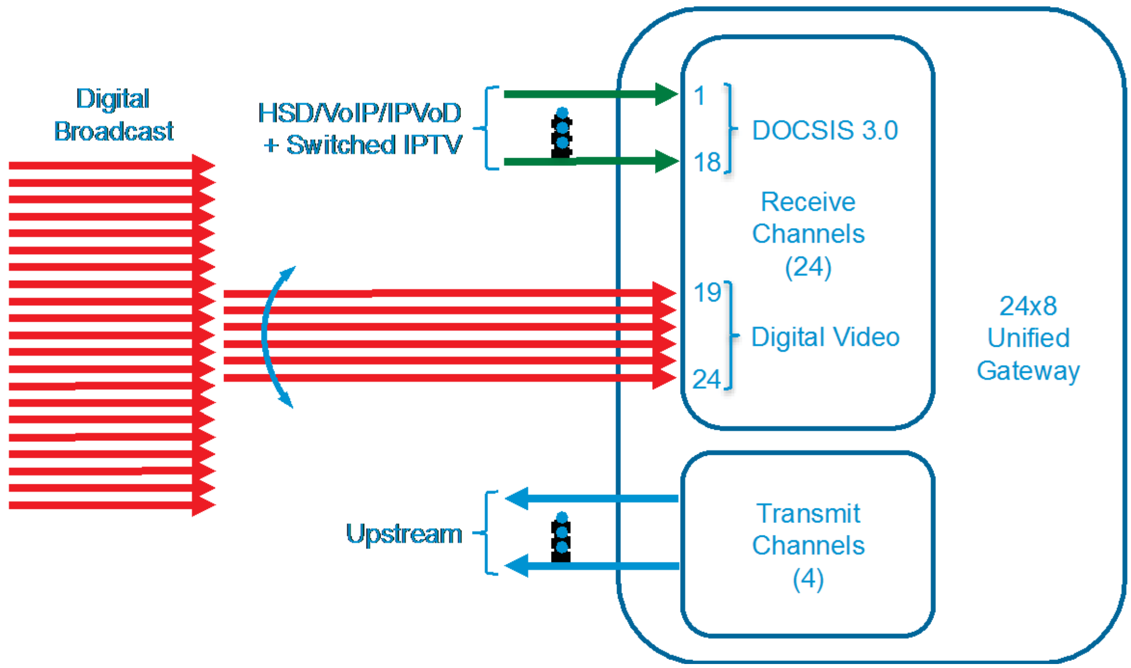

Figure 18. Unified Gateway

Conclusions

The viewership data collected from early cable IPTV deployments demonstrates the continued popularity of Linear TV services. The viewership patterns in the IPTV deployments are similar to the those observed in SDV deployments, with an overwhelming majority of subscribers viewing the short tail content, especially during prime time. Using IP multicast delivery in accordance with DOCSIS 3.0 specifications, the operators achieved multicast gains as high as nine-fold in the largest SGs, resulting in significant savings in CMTS cost and HFC spectrum compared to unicast delivery. In fact, with viewership statistics similar to those presented in this paper, delivering all Linear IPTV services via unicast would be practically infeasible given the amount of HFC spectrum and CMTS capacity required. Current CMTS solutions give operators the choice to employ IP multicast in broadcast and/or switched architectures to deliver Linear IPTV services. The All-Broadcast approach is highly efficient and cost-effective from a CMTS perspective, but operators may not be willing to allocate the required HFC spectrum in order to optimize the CMTS cost. The All-Switched approach is the most efficient from an HFC spectrum perspective, but requires considerably more CMTS capacity than the All-Broadcast approach. The Broadcast+Switched approach enables operators to enjoy the benefits of both approaches while minimizing the trade-offs of each.

The QAM replication feature of CCAP solutions simplifies the implementation of broadcast and switched IPTV architectures, and enables a graceful migration to an all-IP network. New connected home solutions offer greater flexibility in allocating receive channels for IPTV services. These advancements further improve the viability of delivering IPTV services over cable networks.

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Abbreviations and Acronyms

CBR	Constant Bit Rate
CM	Cable Modem
CMTS	Cable Modem Termination System
DOCSIS	Data over Cable Service Interface Specification
DS	DOCSIS Downstream Channel
DVR	Digital Video Recorder
HFC	Hybrid Fiber Coax
HSD	High-Speed Data
IPTV	Internet Protocol Television
IPVoD	Internet Protocol Video on Demand
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
SDV	Switched Digital Video
SG	Service Group
UGW	Unified Gateway
VBR	Variable Bit Rate
VoIP	Voice over IP