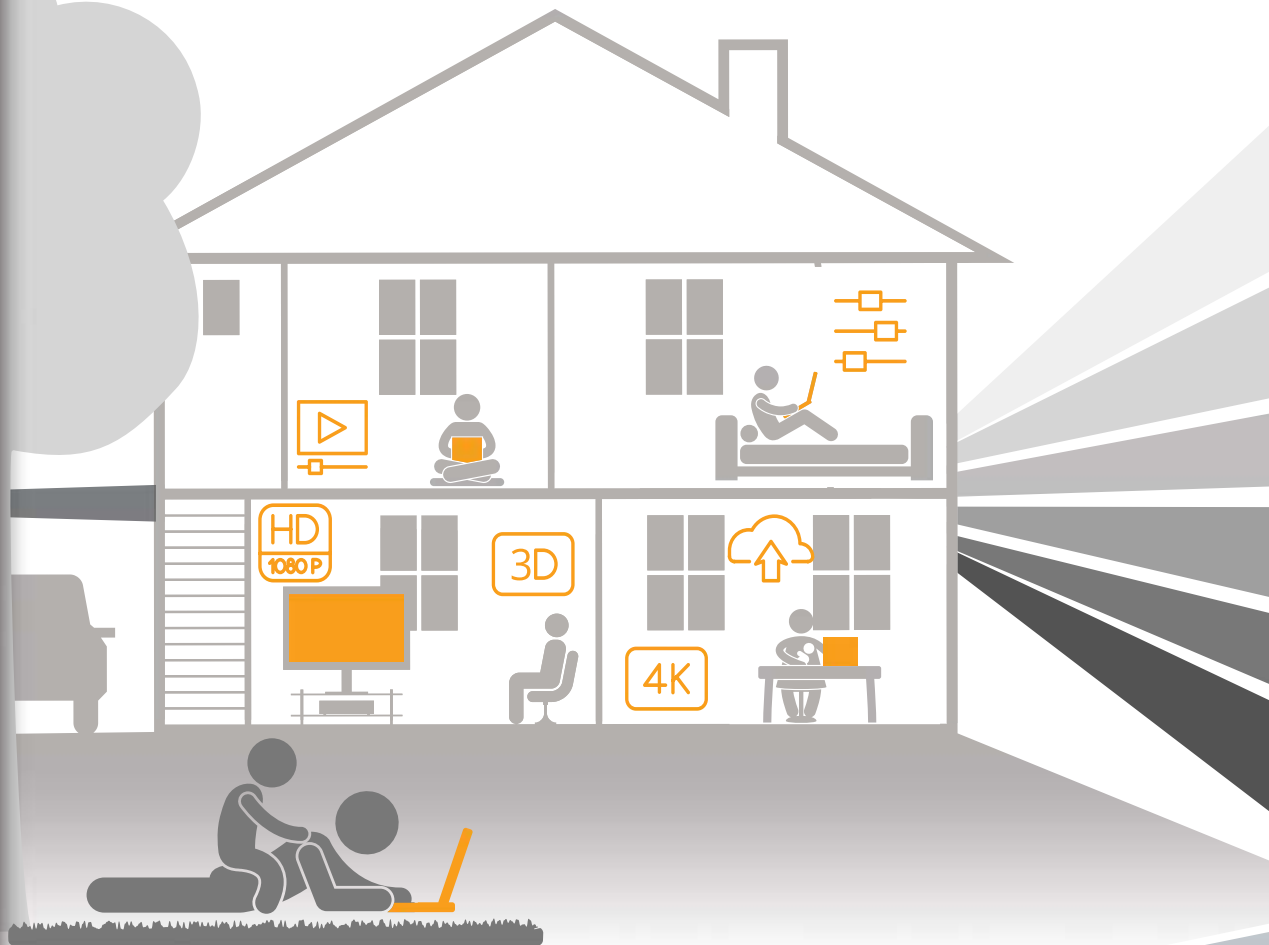


BEHIND THE
SOLUTION



MIGRATING TO DOCSIS® 3.1

Delivering High-bandwidth Gigabit Services
with No Plant Upgrades Required



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Finding Spectrum: Leveraging Switched Digital Video Downstream and DOCSIS 3.1 Upstream to Enable a Cost-effective Evolution Path

In the quest to deliver new and innovative services at Gigabit speeds, Service Providers face a number of challenges. They must be well equipped to meet the needs of a new application landscape, and to handle massive video and IoT traffic growth in order to ensure the optimal end user experience. DOCSIS 3.1 is the technology that can make it all happen.

When it comes to DOCSIS 3.1 evolution, mapping out a successful migration path can be a complex initiative. Each Service Provider has its own architecture, budget constraints, service mix, schedule and legacy solutions that factor into the mix. Therefore, the journey to DOCSIS 3.1 is unique for each and every one of them.

The Problem: Not enough spectrum

We call it a journey because it will not happen overnight. Most often, even when the migration path to DOCSIS 3.1 is carefully mapped out in a way that suits each Service Provider's individual situation, a new challenge arises. One such challenge lies in the spectral limitations of today's HFC networks.

Most often, there is not enough spectrum to devote to DOCSIS for Gigabit services. There will likely be a gradual changeover from legacy to IP video, but both delivery types will need to coexist throughout this transition. In the past, many Service Providers looked to their analog channel lineups for relief, managing and reclaiming, realigning and removing any analog services in order to free up spectrum. But now that this is done, how can additional downstream (DS) spectrum be found? This question is causing Service Providers to carefully consider their mix of legacy and new technologies.

Upstream (US) bandwidth needs are increasing as well. Many Service Providers will want to offer a 100 Mbps US tier to pair with their 1 Gbps DS tier. But in many Service Provider plants,

SOLUTION BENEFITS

Service Providers can leverage existing HFC plants with no plant upgrades

- Switch Digital Video generates significant downstream spectrum savings
- Freed up downstream spectrum used for DOCSIS 3.1 OFDM supports Gigabit services
- DOCSIS 3.1 OFDMA in the upstream enables companion 100Mbps upstream tier

there is not enough usable spectrum for DOCSIS 3.0 in existing 42MHz upstream to achieve a 100 Mbps tier.

ARRIS ServAssure® Advanced Performance Management

- DOCSIS IP service through monitoring of network elements
- Quality of Service (QoS) reports on RF performance, bandwidth consumption, theft and more
- Real-time views and action tools for rapid troubleshooting and resolution
- Mobile UI that allows technicians to check service before leaving the home
- QoS views into preventative maintenance needs for proactive plant management

The Impact: Service Providers must devise a way to find spectrum for DOCSIS 3.1 while maintaining legacy services

If Service Providers are not maximizing their use of spectrum, they won't be able to maintain high-quality subscriber services during the evolution. Adding to the pressure of maintaining a level of service that subscribers have come to expect, is the steadily rising demand for "billboard bandwidths." If quality of experience declines, customer churn is inevitable, putting the entire business at risk.

As Service Providers begin to deploy DOCSIS® 3.1, they must intelligently allocate their spectrum between DOCSIS and legacy video services. During this stage, there are additional trade-offs in selecting the spectrum between DOCSIS 3.0 and DOCSIS 3.1 as well. Many of the fastest high-speed data tiers will be delivered via the spectrum allocated to DOCSIS 3.1. This strategy allows some DOCSIS 3.0 SC-QAM channels to be migrated to DOCSIS 3.1 OFDM to take full advantage of the spectrum within the plant. How much DOCSIS 3.0 spectrum can be reclaimed is a complex function dependent on variables such as service tier mix, size of service group and total spectrum available to DOCSIS.

A Real-life Example: Offering 1 Gigabit services to succeed in a competitive market

One of the largest Service Providers of broadband and video communications in the United States recognized that it was time to leverage DOCSIS 3.1 in order to enhance its delivery of subscriber services. Pay television, telephony, Wi-Fi hotspot access, proprietary content and advertising are the services currently enjoyed by the provider's residential and business customers.

In order to continue to thrive in an ultra competitive environment, our Broadband Communications Provider customer understood that eventually it would need to offer 1 Gigabit services, which wouldn't be possible with its current DOCSIS 3.0 infrastructure. The

proposed solution included expanding switched digital video (SDV) capabilities to free downstream spectrum for DOCSIS 3.1 and also transitioning to DOCSIS 3.1 in the upstream to support 100 Mbps upstream services using the existing spectrum. The near-term upstream goal was to generate at least 120-125 Mbps of capacity to cover upstream bandwidth needs.

The Broadband Communications Provider recognized the benefit from using existing 5-42 MHz plant without needing to invest in costly upgrades at this point in the journey to DOCSIS 3.1.

Behind the Solution: The ARRIS Switched Digital Video approach and DOCSIS 3.1 OFDMA enable Gigabit services in the downstream

Regardless of the migration path Service Providers take, most effective strategies will have one thing in common: the tight synchronization between the introduction of next-generation capabilities and the continuing support of legacy services. One approach that enables Service Providers to strike this delicate balance is the deployment of SDV. This approach helps to utilize video spectrum as efficiently as possible by enabling Service Providers to scale back the amount of spectrum that is allocated to legacy video QAM channels, without reducing the number of programs available to subscribers.

SDV works by only sending less-frequently watched programs over the network when a viewer requests them. Hence the term “switch” for placing watched programs on the network and then removing them when not being watched. These less popular programs are often referred to as the “long tail.” Since only a portion of the programs are being sent down the network, Service Providers can achieve a significant bandwidth savings for their legacy broadcasting capabilities and reclaim valuable spectrum.

ARRIS Network Capacity Modeling Tool

- Comprehensive tool integrating all services:
 - High speed data (HSD)
 - Legacy video – broadcast, VOD
 - Switched digital video
 - IP video
- Full spectrum and capacity analysis
 - Integrates DOCSIS 3.1 and DOCSIS 3.0 bandwidth
- Industry leading QoE traffic modeling
 - Define service tiers with confidence
- Industry leading multicast modeling
 - Used for SDV and IP video

The amount of spectrum savings is dependent on many factors including: the number of programs being offered; the number of viewers in the service group; the users' viewing patterns and the number of edge QAM channels available for the SDV content. ARRIS provides an industry leading, state of the art network capacity modeling tool to provide guidance to Service Providers on how much spectrum they may expect to gain.

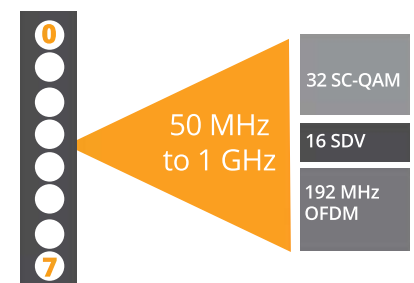
SDV technology has been around for nearly 10 years. Back then EQAMs were relatively expensive with limited channels per port, resulting in very large service groups and limited EQAM channels. In this real life case study, the Broadband Communications Provider had originally configured the SDV system with approximately 1200 subscribers per SDV service group and six SDV EQAM channels. This allowed them to move 150 standard definition (SD) long tail programs out of 400 total, and 18 high definition (HD) long tail programs out of 178 total, onto the switched tier. That's almost 30% of all programs moved to SDV for a total spectrum savings of 84 MHz. This level of spectrum savings was considered optimal when SDV was first deployed.

In the case of the Broadband Communications Provider, ARRIS brought the SDV services onto its Converged Cable Access Platform (CCAP™) to align the service groups for its broadband and video offerings, creating smaller service groups. The provider can now easily leverage CCAP capabilities to add more EQAM channels via software. The smaller service group with the increased SDV EQAM generates greater spectrum savings without the requirement for the ARRIS customer to upgrade any part of its cable plant.

With the help of the ARRIS Network Capacity Modeling Tool, we developed a plan to integrate the SDV EQAM into the CCAP. As the SDV EQAM is integrated inside the CCAP, the Broadband Communications Provider now has more control over the size of the SDV service groups and number of SDV EQAM channels. This allowed the SDV service group size to be reduced to about 300 video subscribers and be aligned with the DOCSIS service group going forward. The number of SDV EQAMs was also increased to 12 channels with a simple licensing software update and no additional hardware changes. This now allows more than 75% of the SD and HD programs to be moved to SDV yielding a potential total spectrum savings of 342 MHz. From another point of view, the Broadband Communications Provider gains an additional 258 MHz beyond today's SDV savings. That's more than enough to add an entire 192 MHz DOCSIS 3.1 OFDM downstream channel to enable Gigabit services.

CCAP products such as the E6000 Converged Edge Router is a game changer for SDV technology. As the service group

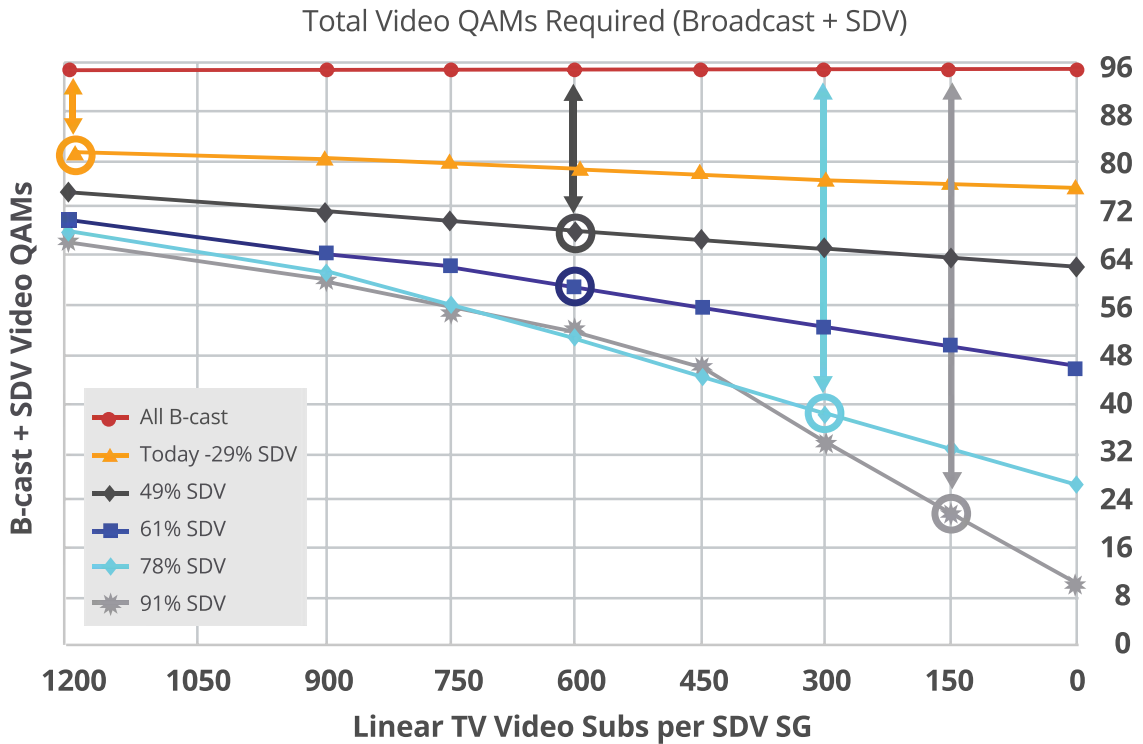
DOCSIS 3.1 Downstream Launch with No E6000 Hardware Upgrade



E6000 Gen 1 DCAM

size continues to get smaller and SDV EQAM increases, the spectrum savings continues to grow. Simply by splitting the service group in half to 150 subscribers could allow for more than 90% of the programs to be put on SDV for up to 438 MHz in total savings. A side benefit of integrating SDV EQAM into the CCAP is that it also frees up significant space and power in the headend by eliminating the need for external EQAM hardware and the associated RF combining network.

ARRIS Network Capacity Model: Potential SDV Spectrum Savings



Once the SDV service group is aligned with the smaller Service Provider data service group, and the EQAM is integrated inside the I-CCAP box, Service Providers can control updates simply with the software’s capabilities, and without the need for any hardware upgrades. This is also the case when adding support for DOCSIS 3.1 OFDM channels. Service Providers can simply re-configure the E6000 to add the enhanced SDV capabilities and then turn on the new DOCSIS 3.1 OFDM channel in the saved spectrum to enable Gigabit services.

Supporting 1 Gigabit downstream and 100 Mbps upstream tiers with limited spectrum availability and no plant upgrades

The challenges in the upstream for the Broadband Communications Provider were different. Most of the usable 42 MHz was already allocated. In this case, the provider had already deployed four DOCSIS 3.0 upstream channels of 6.4 MHz, 64-QAM modulation. While this supplies approximately 100 Mbps of total upstream capacity, the ARRIS model showed that at the current

service group size and proposed service tiers, the Broadband Communications Provider would need 120-125 Mbps of total upstream capacity over the next couple years to offer a quality 100 Mbps upstream tier to pair with the 1 Gbps downstream offering. Along with the four DOCSIS 3.0 SC-QAM channels, additional US spectrum was consumed by set-top box out-of-band channels for both DAVIC and DSG. Some additional guard bands were also not usable. It appeared as though there was no usable spectrum left to add the additional capacity to offer the 100 Mbps US service tier.

DOCSIS 3.1 to the rescue. It's an extremely robust technology with multiple enhancements over its predecessor, DOCSIS 3.0 upstream technology. The latest version of the communications standard uses OFDMA technology that can wrap around existing spectrum utilization. The OFDMA channels with 25/50 KHz subcarriers help significantly with noise mitigation. DOCSIS 3.1 also introduces an improved forward error correction algorithm called LDPC. This gives Service Providers another 5-7 dB in signal to noise ratio. This means that DOCSIS 3.1 provides more capacity (i.e. higher bps/Hz) and can operate in noisier environments where DOCSIS 3.0 cannot. Our studies show that 71% of the existing modems would be capable of operating at 512- or 1024-QAM modulation if using DOCSIS 3.1. This is a 50% to 67% improvement over the 64-QAM modulation of DOCSIS 3.0.

The proposed ARRIS solution was to “borrow” 3.2 MHz of spectrum from DOCSIS 3.0 and wrap DOCSIS 3.1 in the 35-42MHz and 5-9MHz regions. Existing DOCSIS 3.0 services had slightly reduced total capacity of 91 Mbps from three 6.4MHz channels and a 3.2 MHz channel. But the ARRIS model showed that it would still easily support the 50 Mbps upstream service tiers on DOCSIS 3.0. DOCSIS 3.1 modems gained an additional 39-51 Mbps from the OFDMA channel, mostly from the 35-42MHz band. The OFDMA capacity is then bonded with the DOCSIS 3.0 capacity to provide 130-142 Mbps of total capacity. The net total capacity will then be sufficient to offer a quality 100 Mbps US service tier.

Mixed OFDMA/SC-QAM Summary Table
Supporting 100 Mbps Upstream Tiers in 42 MHz

Scenarios	SC-QAM		OFDMA		Total SC-QAM + OFDMA	Tavg_sg @ 200 subs	US Tavg 2-year CAGR	Or Years @ 30% CAGR
	6.4MHz, 64-QAM	Mbps	Mbps	MHz	Mbps	Mbps	%	Yr
Typical SG	3.5	~91	39-51	10-11	130-142	≤46-49	~45%	~2.7-3.0 yr
Corner Cases:								
Bad Case - Noisy Plant	3.5	82	39-45	10-11	121-127	≤38	30%	~2 yr
Good Case - Clean Plant, no 50M	3.5	~91	47-53	10-11	138-144	≤54	~55%	~3.33 yr

The Result: A more efficient utilization of spectrum enables the delivery of high-bandwidth services with no plant upgrades required

With a successful enhancement to the existing SDV system and a transition to DOCSIS 3.1, the Broadband Communications Provider is now able to provide users with 1 Gbps DS services and a companion 100 Mbps US service in a highly competitive market. The increase in usable spectrum savings through SDV enables the introduction of a DOCSIS 3.1 192 MHz OFDM channel in the downstream with no hardware upgrades required. The introduction of DOCSIS 3.1 OFDMA channel in the upstream combined with a slight reclamation of DOCSIS 3.0 bandwidth will provide enough upstream capacity for the coming years. Just as importantly, the Broadband Communications Provider is able to accomplish this goal without a single change to its outside cable plant.

This visionary provider is a leader in aggressively using SDV to find DOCSIS 3.1 OFDM spectrum for Gigabit downstream services, as well as implementing DOCSIS 3.1 OFDMA in the 5-42 MHz upstream plant for a companion 100 Mbps service.

The business objective of DOCSIS 3.1 migrations is typically to help ensure service continuity, maximize bandwidth gains and minimize costs in support of the higher goal to continuously meet and exceed subscriber expectations. While there is no one correct path for a migration to DOCSIS 3.1, Service Providers can embark on a successful journey to DOCSIS 3.1 that makes the most of their existing infrastructure and sets them up for years of service growth.

ARRIS: Behind The Solution

Integrating DOCSIS 3.1 into existing networks can be an overwhelming journey. ARRIS Professional Services can help you optimize spectrum utilization in the upstream and downstream to minimize the impact on subscribers during the transition. We work with our customers to develop and implement a multi-phased migration plan that's optimized for each Service Provider's specific budget, schedule, service goals and subscriber base.

To learn more, visit www.arris.com/solutions/docsis-3-1-migration/