APPLICATION NOTE

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Management's Role in Addressing DOCSIS 3.0 Upstream Challenges

Bonding in the Return Path Requires Top-Level Vigilance to Ensure Optimal Outcomes

Management's Role in Addressing DOCSIS 3.0 Upstream Challenges

Overview

As MSOs act to address surging demand for upstream bandwidth by implementing DOCSIS 3.0 channel bonding on HFC return paths, they face a set of technical challenges that will tax their operational skills to a much greater extent than has been the case with downstream bonding.

Fundamentally, operators' upstream success with DOCSIS 3.0 heavily depends on how they apply the upstream capacity expanding techniques of DOCSIS 2.0. Under-utilization of DOCSIS 2.0 will lead to less than optimal results with DOCSIS 3.0, resulting in a missed opportunity to get the maximum return on the upstream bonding investment.

It's essential that Network Planners who want to get the most out of DOCSIS 3.0 become sufficiently well versed in the complex relationship between these two generations of cable broadband technology to ensure that technical staffs take into account all that needs to be done to maximize the return on DOCSIS 3.0 upstream bonding investments. Unfortunately, while DOCSIS 2.0 is a widely deployed and mature technology, many aspects of the platform have gone largely unused, resulting in a less than thorough understanding of its benefits, even among engineers.

The focal point of oversight is the node characterization process, which all operators must undertake in order to identify which unused spectrum regions in the 5-42 MHz band (or, in the case of European cable, the 5-62 MHz band) are best suited for adding channels to reach the four-channel bonding minimum, and what the optimal performance parameters will be for each of the selected channels. While attaining such information may seem to be a fairly routine process for the average field team, node characterization for DOCSIS 3.0 is anything but routine.

To accurately determine which channels are best suited for bonding and what the optimal channel widths and modulation rates are for each requires a thorough analysis of how the techniques available in DOCSIS 2.0 might bear on the performance potential of individual channels as well as on their aggregate performance as a bonded whole. Because so many DOCSIS 2.0 techniques are not in use today, most engineering teams are not equipped to run the required tests or to perform the analysis that will lead to an understanding of what the true upstream capacity on bonded channels might be.

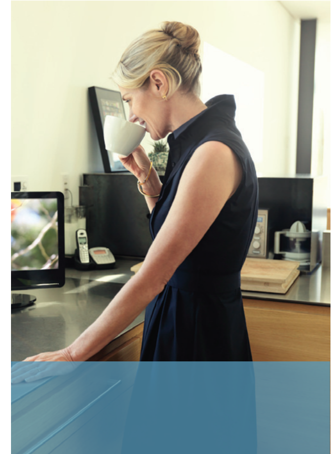
Fortunately, cable operators can benefit from the vast amount of field experience Motorola has amassed in utilizing all facets of the DOCSIS 2.0 toolkit over many years of customer engagements worldwide. Now the company is applying this systems expertise to DOCSIS 3.0 node characterization projects with execution of the test procedures and analytical capabilities that are essential to delivering a full picture of what the upstream capacity potential is within any given HFC environment. Motorola has applied these advanced methodologies across multiple different vendor solutions in major node characterization projects with more than a dozen Tier 1 MSOs worldwide.

The following highlights the key areas to consider in order to maximize upstream channel bonding implementations.

Leverage DOCSIS 2.0 Techniques to Expand Channel Widths

The target operators should shoot for when implementing DOCSIS 3.0 is 6.4 MHz per channel for all four channels at 64 QAM modulation, which translates to a maximum per-channel capacity of 28.3 megabits-per second or a total of 113.2 Mbps maximum across all four bonded channels. While upstream utilization varies considerably from one MSO to the next, operators typically are running two to three channels with channel widths of 1.6 or 3.2 MHz and modulation set at 16 or 32 QAM. In some cases one of the channels measures 6.4 MHz operating at 32 or 64 QAM which yielding an aggregate upstream bandwidth of between 17 and 50 Mbps which is well short of the potential.

One widely held assumption is that in order to accommodate four upstream channels in the commonly used spectrum zone between 20 and 42 MHz, operators must restrict upstream channel widths to 3.2 MHz per channel. This view overlooks the fact that one of the key components of DOCSIS



Operators must be able to judge whether their adjustments will produce results that are worth the investment.

2.0, known as Synchronous Code Division Multiple Access (SCDMA), was designed to open the lower 5-20 MHz spectrum tier, where ingress RF noise is a significant impediment for traditional DOCSIS multiplexing modes. SCDMA is not the only underutilized DOCSIS 2.0 element that can help increase upstream capacity.

When multiple DOCSIS 2.0 techniques are put to use, Motorola's experience with cable operators has proven that most will be able to operate at 6.4 MHz channel widths over all four channels, including any channel designated for SCDMA multiplexing below 20 MHz, with modulation rates set at either 64 or 32 QAM. Even at 32 QAM, the data rate on a 6.4 MHz channel is 26 Mbps, which means that, minimally, most operators can expect to hit 104 Mbps over four channels, if not the optimum 113.2 Mbps.

Assess the Adequacy of Upstream Lasers

Along with DOCSIS 2.0 tools, another factor in determining the upstream capacity potential is an operator's choice of lasers. Many operators who have managed to continue using older Fabry-Perot lasers to meet upstream requirements will find these devices are not suited to operating in multiple spectrum frequencies with sufficient output power to meet DOCSIS 3.0 requirements. This presents an opportunity to upgrade to distributed feedback lasers (DFBs), the types of lasers traditionally used for downstream transmissions, as opposed to upgrading to a newer generation of Fabry-Perots.

Operators using Fabry-Perots that can meet minimum DOCSIS 3.0 requirements may find it's worth the cost of shifting to DFBs, given the extraordinary capacity gains that can be attained in conjunction with using all DOCSIS 2.0 tools. Operators may also want to consider higher performance varieties of both DFBs and Fabry-Perots as part of this analysis.

Each operator will have their own calculus to apply in the cost-benefit analysis. The key is that the node characterization process should include an assessment of the performance variations in conjunction with DOCSIS 2.0, which Motorola makes easy to do by providing a means of testing alternative lasers in the field without disrupting existing service.

Make Sure all the Bases Are Covered in Node Analysis

Not only must operators take into account the full range of DOCSIS 2.0 capabilities in the context of performance variations of different types of lasers. They must also consider the complex, inter-related factors of second and third order distortion, microreflections and other measured plant conditions.

For example, the negative impact of microreflections increases dramatically with expansions in channel width, which brings into play analysis as to whether, for a given channel width, an operator may need to employ the pre-equalization process available on DOCSIS 2.0. Or, to take another example, operators must consider cable modem return transmission power levels when measuring the results of forward error correction, since it's often possible to change an unacceptable FEC result to acceptable if there's margin to increase CM power. Further complicating matters in this regard, available power margins on CMs for any given level of second and third order distortions can vary based on where they are operating in the available spectrum region and what order of modulation is used.

One of the most important nuances in the capacity analysis pertains to calculating how the expanded dynamic range requirements associated with channel bonding will impact operating margins. Just because tools currently in use allow the operator to achieve an acceptable signal-to-noise level over, say, a 6.4 MHz channel operating at 64 QAM, doesn't mean those tools will be sufficient when that channel is bonded with several simultaneously operating channels.

The list goes on. The essential point to keep in mind is that operators must thoroughly analyze how all the return path performance metrics will be affected with the application of the techniques in the DOCSIS 2.0 toolkit. Needless to say, in order to do this, technicians must have a full understanding of all DOCSIS 2.0 components and how to orchestrate their use to maximize performance under a given set of conditions. And they must be able to judge whether adjustments, such as an upgrade in return transmitters or a reduction in amplifier cascades, will produce results that are worth the investment.

Motorola's Node Characterization Program

Motorola's Node Characterization Program provides the operator with a comprehensive network analysis and recommendations for optimizing upstream throughput. Field measurements taken over a period of days at multiple nodes serve to present a full picture of how the plant is performing at all hours. Motorola teams use a wide range of equipment in the measuring process, including off-the-shelf as well as proprietary gear. Critically, they employ portable CMTSs and CMs to avoid service disruptions as well as any reliance on friendly users.;

The Motorola Node Characterization Program includes nodes from multiple equipment manufacturers and measures all the nuances associated with laser performance analysis. The analysis includes characterization of path distortions and ingress noise that go well beyond traditional measurements; microreflection assessments that take into account the impact of pre-equalization, and much else that is not included in the usual node characterization process.

Motorola is able to determine how the use of various DOCSIS 2.0 techniques on any given channel will affect all these performance parameters by employing the logical channel mode of operation that is part of the DOCSIS 2.0 toolkit. This seldom-used capability allows Motorola to run tests using DOCSIS 2.0 multiplexing techniques over RF channels currently in use by DOCSIS 1.x modems, with no disruption to service.

Conclusion

Full utilization of DOCSIS 2.0 techniques in conjunction with a move to DOCSIS 3.0 channel bonding in the upstream path provides cable operators an opportunity to vastly expand the capacity of their offerings to end users. The difference between what can be done optimally versus what may appear to be doable without a full understanding of the impact DOCSIS 2.0 elements might have on capacity expansion is too great to ignore.

A complete assessment of the possibilities may lead some operators to upgrade lasers, reduce amplifier cascades or take other steps to lower impediments to realizing the full potential of DOCSIS 3.0. In other cases, operators will find no upgrades are necessary to get to aggregate upstream data rates above 100 Mbps, so long as they fully exploit the capabilities of DOCSIS 2.0.

There may be no better method to reach assurance that implementing DOCSIS 3.0 upstream bonding will produce optimal results than to engage Motorola to execute the node characterization process. But, whether or not that step is taken, Network Planners must be especially vigilant to ensure that no stones are left unturned in the pursuit of the highest possible upstream service rates.

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