Originally appeared in the **July 2008** issue of *Communications Technology*.

FINDING SPECTRUM FOR CHANNEL BONDING

By RON HRANAC

The latest iteration of Data Over Cable Service Interface Specification - DOCSIS 3.0 - has been in the news recently. Several cable modem termination systems (CMTSs) and cable modems have received qualification and certification respectively from CableLabs, and pre-DOCSIS 3.0 channel bonding deployments have been up and running for more than a year.

A key benefit of DOCSIS 3.0 technology is the ability to overcome the per-channel data rate limitations of DOCSIS 1.0/1.1 and 2.0, using something called channel bonding. Channel bonding allows multiple RF channels to be used to transmit data to and from cable modems by spreading the payload across those channels. As I've noted in this column in the past, channel bonding doesn't involve creating one gigantic digitally modulated signal - the bonding is logical. For instance, if one were to use eight 6 MHz bandwidth downstream 256-QAM (quadrature amplitude modulation) channels at 42.88 Mbps each in a channel bonding scenario, the raw data rate to modems would be 8 x 42.88 Mbps = 343.04 Mbps. In the upstream, one could bond, say, four 6.4 MHz bandwidth 64-QAM channels for a raw data rate of 4 x 30.72 Mbps = 122.88 Mbps.

Quick side note: In order for equipment to be DOCSIS compliant, it must support bonding of at least four channels. (There is no upper limit to the number of channels that can be bonded.) However, a cable operator doesn't have to bond four channels to take advantage of DOCSIS 3.0's increased throughput. Two, three, or any other number is fine.

One question that inevitably comes up in a discussion about DOCSIS 3.0 is "Where do I get the RF spectrum needed to carry additional channels to support channel bonding?" If the spectrum in your plant is already filled to the rafters, there are two answers: Bandwidth optimization and bandwidth enhancement. The former involves improving the efficiency of existing spectrum usage, and the latter boils down to expanding the cable network's RF spectrum. Let's look at each of these in a bit more detail.

Bandwidth optimization

There are a number of ways to optimize the use of existing spectrum and free up a little extra RF bandwidth to support DOCSIS 3.0. It's best to think of the following as tools in a toolbox. Each has advantages and disadvantages, and one tool alone may not be an ideal solution. Indeed, a combination of approaches often yields the best bang for the buck, depending on how much spectrum one is trying to make available.

One obvious way to optimize the use of existing RF bandwidth is to squeeze more bits into each channel. If you haven't done so already, consider migrating all downstream 64-QAM channels to 256-QAM. This increases the per-channel raw data rate from 30.34 Mbps to 42.88 Mbps and can potentially free up some spectrum. How? The payload of four 64-QAM channels (4 x 30.34 Mbps = 121.36 Mbps) can be carried in three 256-QAM channels (3 x 42.88 Mbps = 128.64 Mbps). A second option is to improve the effective throughput per channel (think more video streams per channel) using channel grooming. This includes things such as dual pass encoding with rate control, remultiplexing, and re-statmuxing (transrating). A third option is the use of more efficient MPEG standards-based digital compression such as MPEG-4, although a potential drawback to the latter is the need for MPEG-4 compatible set-top boxes.

Switched digital video (SDV) sends programs to subscribers only in areas where programs are being requested in real-time. A number of cable operators have successfully deployed SDV, and anecdotal evidence suggests that some RF bandwidth can be freed up with SDV - perhaps as much as 5 to 15 percent. Your actual mileage may vary, of course.

Analog reclamation is yet another tool in the bandwidth optimization toolbox. For instance, digitizing and compressing 10 analog channels into one digital channel frees up nine 6 MHz channel slots. Potential cons? Contracts with programmers and the local franchise agreement may present some challenges. There are also potential must-carry issues, plus the need for digital set-tops for those subscribers who want to receive the newly digitized services.

A few cable operators have made the jump to or are considering all-digital operation. Doing so can potentially free up substantial spectrum, but requires digital set-tops for most subscribers. Like analog reclamation, one must sort out the logistics of programming contracts, franchises, must-carry, and possibly also Federal Communications Commission waivers. Technically, though, going all-digital is doable.

Bandwidth optimization can initially free up some channel slots and is a good short- to medium-term solution that allows relatively quick deployment of DOCSIS 3.0 channel-bonded services. However, as even more channels are bonded, other new services and content are added, SDV penetration increases, the number of set-tops per sub goes up, and so on, the need for more RF spectrum will once again be a factor. This, of course, makes for a convenient segue to the second way to get additional RF spectrum: bandwidth enhancement.

Bandwidth enhancement

What's the upper frequency limit of your cable network? 750 MHz? 860 MHz? Bandwidth enhancement is the expansion of a cable network's upper frequency limit to 1 GHz. It's not the same thing as the plant upgrades or rebuilds the industry did in the 1990s. Instead, it's a drop-in electronics replacement with 1 GHz nodes, amplifier modules, analog optics and headend equipment.

Bandwidth enhancement in a 750 MHz plant provides up to 42 additional 6 MHz channel slots: (1,002 MHz - 750 MHz)/6 MHz = 42 channels. It's cost effective because it uses existing products, involves little or no new training, and is less than 20 percent the cost of an HFC upgrade. Bandwidth enhancement is relatively easy because it uses drop-in technology. This means reduced labor, typically less than 30 percent of the labor of an upgrade.

What does bandwidth enhancement get? A cost-effective increase in the available RF spectrum (252 MHz of new spectrum in a 750 MHz plant!), the ability to deploy DOCSIS 3.0's bonded channels, and headroom for new service offerings. There is also no reason why bandwidth optimization cannot be combined with bandwidth enhancement, yielding the best of both worlds. Advanced compression, 256-QAM, SDV, analog reclamation, and even migrating to all-digital can still be done in a bandwidth enhancement scenario. This results in even more available spectrum to accommodate new high definition TV (HDTV), video on demand (VOD), and commercial services.

Some operators have been looking at increasing the upstream spectrum from 5-42 MHz to something like 5-65 MHz or even 5-85 MHz. This could be done at the same time that the forward path is increased to 1 GHz, although changing the frequency split is probably going to be easier said than done. If the actives have plug-in diplex filters, the job will be fairly straightforward. If the diplex filters are hardwired into the chassis or motherboard, a frequency split change will get complicated real fast.

Bottom line

As mentioned earlier, bandwidth optimization is a good short- to medium-term solution for accommodating DOCSIS 3.0's channel bonding technology. Bandwidth enhancement can be thought of as a good medium- to long-term solution. Some might even argue that bandwidth enhancement is inevitable. From that perspective, it may well be the most cost-effective way to get more RF bandwidth.

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