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DOCSIS 3.0: HOW TO WEIGH THE COSTS AND BENEFITS

By RON HRANAC

The opportunities for cable operators provided by DOCSIS have been pretty much by the numbers: as in DOCSIS 1.0, 1.1, 2.0 and now DOCSIS 3.0. Version 1.0 got the data ball rolling; 1.1 added a number of features, including quality of service (QoS), more robust scheduling, packet classification and other enhancements that facilitate voice services; 2.0 increased upstream throughput; and now 3.0 is here with significant jumps in both upstream and downstream speeds.

While those increases in upstream and downstream speeds from DOCSIS 3.0 are very attractive, they don't come without a price in terms of how they impact the cable access network.

From an access standpoint, the early DOCSIS environment has focused on deployment and maintenance of only one channel to the modem and one channel coming back from the modem. Operators had to be aware of how many subscribers they had and the size of the service area, but bottom line was that they had to worry about one channel in each direction. In the reverse path, the big problems were traffic, ingress and node size: You couldn't make the node size too big, or things might not work reliably.

Channel bonding

Now, DOCSIS 3.0 opens the door for something known as channel bonding. Channel bonding means that data is transmitted to or from modems using multiple individual RF channels instead of just one channel. No, the channels aren't physically bonded into a gigantic digitally modulated signal. Rather, the bonding is logical. As DOCSIS 3.0 cable modems become available, forward path data throughput speeds won't be limited to the current per-channel max of about 38 Mbps. You have the potential to bond four or more channels, so do the math: 4 x 38 = 150+ Mbps throughput.

That's in the forward path. Channel bonding can also occur in the reverse path, but the reverse path modem capability will lag the forward path by one to two years.

DOCSIS 1.0 and 1.1 gave us downstream 64- or 256-QAM (quadrature amplitude modulation) in a 6 MHz bandwidth channel, and upstream quadrature phase shift keying (QPSK) and 16-QAM transmitted in a channel bandwidth up to 3.2 MHz. With DOCSIS 2.0, the ante was raised by adding support for 8-QAM, 32-QAM and 64-QAM capability, plus a wider channel that has been increased from 3.2 MHz to 6.4 MHz. DOCSIS 3.0 includes all of this in addition to the prospect of bonding multiple upstream channels.

So, to execute channel bonding in the access plant, it must be robust enough to support DOCSIS specifications, and operators are going to have to "find" a place to put multiple channels dedicated to channel bonding within their spectrum. This may provide a bigger challenge in the reverse path than is involved in using the forward path spectrum. Additionally, even though existing cable modem termination system (CMTS) equipment can talk to the new 3.0 modems and vice versa, you won't be able to just offer your customers the benefits of 3.0 with legacy CMTSs unless they are upgraded to 3.0 capability.

Modem horsepower

As far as the DOCSIS 3.0 cable modem is concerned, today's one-channel capability will increase to four or more logically bonded channels. This will be mirrored in the reverse path (note that downstream bonding can be implemented without upstream bonding), so there is considerable horsepower coming in the cable modem. This horsepower will come at a premium: Depending on modem design, additional receivers and transmitters will be needed, or complex and powerful digital signal processing (DSP) technology will be used, making 3.0 modems somewhat pricier than their 1.1 and 2.0 brethren. The cost of the modem and the price points that will be established for this new faster service may mean that 3.0 service will ramp up at a slower pace than those of earlier DOCSIS services.

If you look at the forward path, the modem will rely on multiple tuners (and/or DSP) compared to the single tuner in today's modems. For instance, one modem design uses three 20 MHz-wide receivers to make up a 60 MHz window. With this design, the forward path window must consist of a nearly contiguous 60 MHz block of bandwidth, not 20 here, 20 there and 20 somewhere else in your spectrum. You may find yourself "moving things around" to get that 60 MHz of adjoining bandwidth within the 300 to 1,002 MHz range even though the 3.0 specs define the limits as 111 to 867 MHz.

Super premium users

At Scientific Atlanta, most cable operators that have discussed a DOCSIS 3.0 offering with us have indicated that because of the cost of the service (both to the operator to provide and for the user to purchase) and the applicability of this high-speed performance, it's probably only going to appeal to super premium residential users and small businesses. One cable operator estimates those types of users at about five percent of their subscribers. So you're probably looking at an incremental business, and you'll definitely want to keep the 1.1 or 2.0 service as it is for casual Internet users.

Carrier-to-crud

Then you have to take into consideration "carrier-to-crud," including thermal noise ("crud" is everything undesired - thermal noise, ingress, common path distortion, etc.), in the forward path. The DOCSIS Radio Frequency Interface Specification's assumed downstream RF channel transmission characteristics include 35 dB minimum carrier-to-noise ratio (CNR) and 41 dB carrier-to-distortion and interference ratios. This means your QAM carrier at the modem input is assumed to have noise at least 35 dB below the signal's digital channel power level and distortion and interference 41 dB or more down. As you move to DOCSIS 3.0, the carrier-to-crud requirement remains the same as in previous versions of DOCSIS.

Reverse path

DOCSIS 3.0 introduces special challenges in the reverse path. You can have multiple 64-QAM channels, each of which is now supporting a 6.4 MHz-wide carrier. With upstream four-channel bonding, all four modem reverse transmitters will fire at the same time. The lasers may need to be turned down to accommodate the higher optical modulation index. This may result in more energy transferred to the laser, so the backoff needs to be set accordingly. When the backoff to the laser is established, it might mean old Fabry-Perot (F-P) lasers are not adequate and that you may have to buy new reverse distributed feedback (DFB) transmitters to get the performance you need to maintain operating headroom.

The combination of DOCSIS 3.0, channel bonding and the ability to automatically turn down power means you have to tighten the loss structure in the plant and in the home/business to narrow this dynamic range in order to make the modems work properly. That means reverse conditioning, optimizing lasers and amplifier levels for the right windows, and picking the right input levels to the node's transmitter. Products available to help you do a better job of tuning the reverse path for optimal performance are line equalizers with reverse conditioning passives and taps that incorporate reverse pad attenuation at the tap location. The latter will help to improve the upstream carrier-to-junk ratio by forcing modems to transmit at higher levels.

Legacy DOCSIS carriers

In addition to the existing active carriers in the plant for set-top communication, legacy DOCSIS signals and test functions, there are places in your spectrum where it's difficult to operate (5-15 MHz is often considered no man's land because of all the noise and interference that's common at this low frequency). So now you're whittling the available upstream spectrum down to where you may only have 20 to 25 MHz of usable bandwidth. If you're going to bond four upstream channels and each one is 6.4 MHz wide, basic math says that 25 MHz for this application is absolutely borderline. As you begin to reduce the number of bonded channels available, you reduce the capacity to offer high throughput/high revenue services such as servicing local business needs. The resulting plant implications may include driving fiber deeper and splitting node sizes, attempting to change the forward/reverse split in the plant, or migrating to a higher order modulation, all of which may be very expensive and require significant plant downtime. Obviously, there are still a lot of questions that need to be answered in this area.

Been there, done that

In some ways, we've been here before when we went from 64-QAM to 256-QAM in the forward path and frequency shift keying (FSK) (nonDOCSIS) to QPSK to 16-QAM in the reverse path. Every time a change was made, you've had to ensure a clean plant, but this is an evolutionary step rather than a revolutionary change as we have been used to in the past.

Master the DOCSIS 3.0 challenges and you'll have very high capacity payloads: potentially equivalent to 100 Mbps or greater Ethernet pipes. It's the great equalizer to meet passive optical network (PON) data rates by combining channel bonding and smaller node sizes that result in data rates close to what some of the telecom operators say they can deliver.

Start looking at the challenges now. The shift will be gradual, not a rapid shift from one day to the next. But the time to get ready is now. If you wait until the applications are available that drive PON-required data rates, it will be too late.

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