



TECHNICAL COLUMNS

Official archives of articles and columns written by Ron Hranac for Communications Technology and some of its sister publications, published by Access Intelligence, LLC. Reprinted with permission of the author.

By **Ron Hranac**, former **Senior Technology Editor**, **Access Intelligence** and **Communications Technology Magazine**

Originally appeared in the **March 2006** issue of *Communications Technology*.

DOCSIS 3.0

By RON HRANAC

Since its introduction in the 1990s, DOCSIS (short for Data Over Cable Service Interface Specification) has emerged as the leading standard for high-speed data transmission over cable networks. DOCSIS 2.0 is the latest member of the DOCSIS family, but a new version—the subject of this month's column—is in the works.

DOCSIS 1.x

DOCSIS 1.0 provided the cable industry with standards-based interoperability, which means certified cable modems from multiple vendors work with qualified cable modem termination systems (CMTSs) from multiple vendors. DOCSIS 1.1 added a number of features, including quality of service (QoS), more robust scheduling, packet classification and other enhancements that facilitate voice services. Upstream transmission robustness was improved with the introduction of eight-tap adaptive equalization in DOCSIS 1.1 modems.

DOCSIS 1.0 and 1.1, collectively known as DOCSIS 1.x, support two downstream modulation formats: 64-QAM (quadrature amplitude modulation) and 256-QAM. These two modulation formats provide raw data rates of 30.34 and 42.88 Mbps respectively in a 6 MHz wide downstream channel. DOCSIS 1.x accommodates several upstream data rates, ranging from a low of 320 kbps to a high of 10.24 Mbps. It also supports two upstream modulation formats—quadrature phase shift keying (QPSK) and 16-QAM—as well as five upstream RF channel bandwidths.

DOCSIS 2.0

DOCSIS 2.0 brought the cable industry higher upstream per-channel data throughput, increasing the maximum to as much as 30.72 Mbps. Downstream functionality remains largely unchanged, retaining 64- and 256-QAM capability. DOCSIS 2.0 defines the use of 64-QAM in the upstream—plus 8-QAM, 32-QAM and the modulation formats from DOCSIS 1.x—and optionally supports 128-QAM trellis coded modulation (TCM) for synchronous code division multiple access (S-CDMA) channels.

The increased upstream per-channel data throughput available with DOCSIS 2.0 technology is accomplished using higher orders of modulation and increased RF channel bandwidth. Higher orders of modulation than QPSK and 16-QAM require substantially more robust data transmission. This is especially true in the often hostile reverse path RF spectrum used in most cable networks. To facilitate more robust upstream data transmission, DOCSIS 2.0 introduced a set of features called advanced PHY. For more on advanced PHY, see my April 2005 column: www.ct-magazine.com/archives/ct/0405/0405_broadband.htm

Limitations

Despite the improvements that have occurred as DOCSIS has evolved, maximum data rates to and from the modems are pretty much topped out. Competition and the desire to provide new services are driving the need for even greater throughput in our DOCSIS networks. While moving to even higher orders of modulation than 64- or 256-QAM—for instance, 1024-QAM in the downstream—would yield greater throughput, we're still limited by the fact that the maximum raw data rate to or from cable modems is



ultimately constrained by what a single 6 MHz wide channel can carry in the downstream, or what a single 6.4 MHz wide channel can carry in the upstream.

DOCSIS 3.0

Enter DOCSIS 3.0.

According to CableLabs' Web site (www.cablemodem.com), "DOCSIS 3.0 specifications are currently under development ... and will include a number of enhancements, most notably, channel bonding and support for IPv6. Channel bonding provides cable operators with a flexible way to increase upstream and downstream throughput to customers, with data rates in the hundreds and potentially gigabits per second."

Channel bonding

Channel bonding? What the heck is that?

In a nutshell, 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.

Let's say you want to increase the downstream data rate between the CMTS and modems from today's single 6 MHz wide channel limit of 42.88 Mbps. If you were to spread your downstream data payload across four 6 MHz wide channels, the combined data rate using 256-QAM on each channel would be $42.88 \text{ Mbps} \times 4 = 171.52 \text{ Mbps}$. A DOCSIS 3.0 modem will incorporate a special tuner capable of simultaneously receiving data from those four channels. To the modem, the four channels are the logical equivalent of one large bonded channel, even though we're using four physically separate channels. They don't even have to be adjacent channels!

Want more? Bonding, say, 10 channels, will yield $42.88 \text{ Mbps} \times 10 = 428.8 \text{ Mbps}$, and bonding 24 channels works out to $24 \times 42.88 \text{ Mbps} = 1,029.12 \text{ Mbps}$, or just over 1 Gbps. Yikes!

The same channel bonding concept is applicable to the upstream, giving us the ability to go far beyond DOCSIS 2.0's per-channel limit of 30.72 Mbps. How does 120 Mbps or more sound?

IPv6

OK, what about IPv6?

That's an abbreviation for Internet Protocol Version 6, which is the next generation protocol. Most of the Internet currently is based on IPv4, which is quickly approaching its limits. One limitation is the number of available IP addresses. IPv4's use of 32-bit addressing translates to a maximum of around 4.2 billion IP addresses. A variety of tricks have been employed to extend the life of IPv4, but we're still near the end of the IPv4 road.

IPv6 brings a whole bunch of improvements to the protocol, among them the use of 128-bit addressing. IPv6's 128-bit addressing scheme gives us about 3.4×10^{38} IP addresses. If I did my math right, that's 340 followed by 36 zeros.

DOCSIS 3.0 will support IPv6.

When can I have it?

No, you can't go to Circuit City and buy a DOCSIS 3.0 modem just yet. The specification is still under development, although by the time you read this, a draft of the spec should be available from CableLabs under nondisclosure agreement. If you're interested, go to www.cablemodem.com/howto/

DOCSIS 3.0 still has to go from draft stage to final publication, and once that happens, the product availability clock will start ticking. If recent history is any indication, figure one to two years from when the final specification is published to product certification. DOCSIS 1.0 and 1.1 each took about two years to complete this cycle, and DOCSIS 2.0 did it in about a year.

Ron Hranac is technical leader, HFC Network Architectures, for Cisco Systems, and former senior technology editor for *Communications Technology*. Reach him at rhranac@aol.com.