DOCSIS 3.1: ENTER THE GIGASPHERE

By Kurt Marko

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KURT MARKO, is an IT industry analyst, consultant and regular contributor to a number of technology publications, pursuing his passion for communications after a varied career that has spanned virtually the entire high-tech food chain from chips to systems. Upon graduating from Stanford University with bachelor's and master's degrees in electrical engineering, Marko spent several years as a semiconductor device physicist, doing process design, modeling and testing. He then joined AT&T Bell Laboratories as a memory chip designer and CAD and simulation developer. Moving to Hewlett-Packard, he started in the laser printer R&D lab doing electrophotography development, for which he earned a patent, but his love of computers eventually led him to join HP's nascent technical IT group. Marko spent 15 years as an IT engineer and was a lead architect for several enterprisewide infrastructure projects at HP, including the Windows domain infrastructure, remote access service, Exchange email infrastructure and managed Web services.

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LET'S FACE IT: GIGABIT IS THE NEW MEGABIT. CUSTOMERS WHOSE EMPLOYEES CAN BUY FIBER-TO-THE-

premises broadband offerings for their home networks chafe at a 10 megabit Internet link at work — even though that's an order-of-magnitude improvement over T1 and DSL circuits. Think Millennials employees don't notice sluggish performance? They do, and they're not amused.

What's that? No fiber in your area? No worries. The hybrid fiber-coax (HFC) plant used by cable operators for nearly 20 years, deployed at a cost of $200 billion over the decade, has proven quite resilient, capable of scaling to hundreds of digital broadcast channels and 100+ megabit broadband networks. In fact, the next iteration of the venerable DOCSIS, for "data over cable system," standard used to deliver data over cable networks is poised to give last-mile fiber networks a run for their money, starting in earnest this year. Comcast, Cox Communications, Time Warner Cable and other providers are piloting 3.1 initiatives in select areas of the country. There's a snappy new Gigasphere logo (see below). And given the infeasibility of delivering gigabit connections to the bulk of the country without marshaling an army of backhoes, we're betting that the cable industry will continue to squeeze more and more usable bandwidth out of existing HFC systems.

GIGASPHERE

Even symmetrical 1 Gbps per second links are, if not imminent, at least on the agenda.

Now, if customers need gigabit speeds today, fiber is generally your only choice, which explains why FTTH subscriptions are growing at over 50 percent annually. That translates to 12.3 million U.S. homes, and undoubtedly some number of SMBs and branch offices, and represents uptake in about half of the properties that can access direct fiber connections. However, that's a small fraction of the 100 million broadband subscribers, more than half of which use cable.

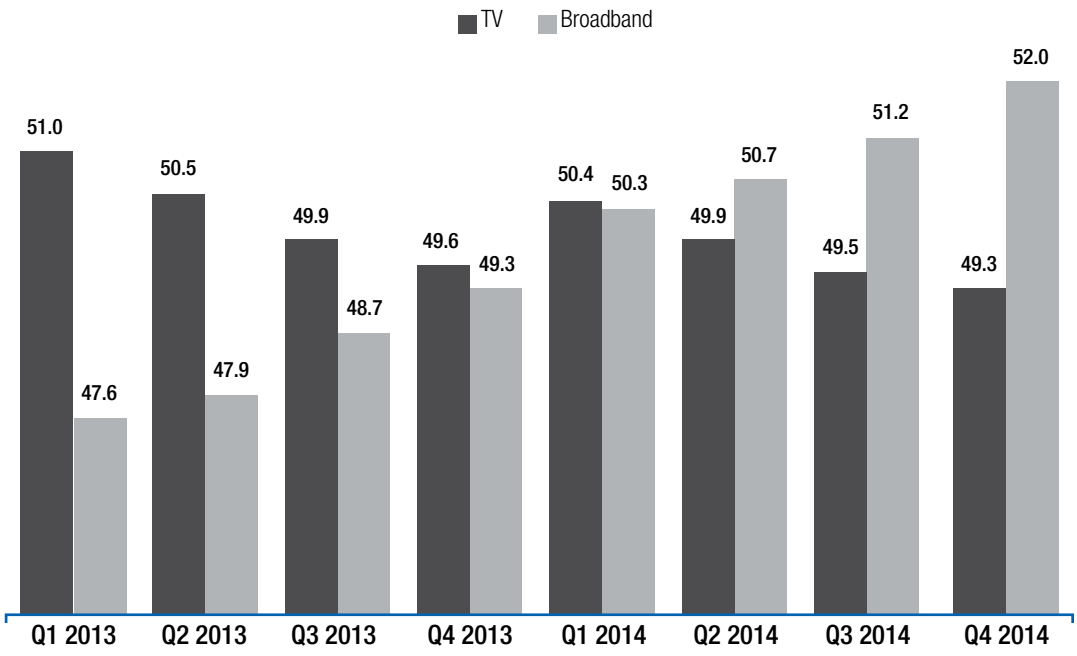
For truly widespread gigabit service, DOCSIS 3.1 is the answer, and this is the year things get real.

DOCSIS 101

DOCSIS was developed in the late 1990s by the cable industry's R&D cooperative, CableLabs, as the standard way to deliver high-speed data over broadcast cable networks. The standard guaranteed a cohesive market for CPE, test and backbone network equipment that helped focus innovation on a single technology road map and drive down costs. The current 3.0 standard was released in late 2006 and is now universally used by cable operators.

US Cable Subscribers by Service, 2013-2014

(in Millions)



Data provided to Leichtman Research Group by select major cable providers indicates that more customers are using cable for Internet subscriptions than TV subscriptions.

DOCSIS works by using one of the 6MHz video channels (in the United States, or 8MHz in Europe) for downstream data and a narrower, low-frequency band for upstream traffic. By employing a quadrature amplitude modulation scheme (QAM), early DOCSIS versions were capable of transmitting 256 points, or 8 bits, of information per analog cycle. With 6MHz of spectrum and subtracting out protocol overhead, error correction and channel guard bands, that yielded 42.88 Mbps of downstream throughput. Using lower, and hence noisier, frequencies for the upstream required a less aggressive modulation scheme that limited bandwidth to 10.24 Mbps.

DOCSIS 3.0 provided a major speed boost via the ability to bond channels, much like Ethernet aggregation that combines multiple switch ports into a larger logical connection. Although the standard supports bonding as many as 32 downstream channels, most systems started with four and later went to eight, for throughput in the 170 Mbps to 340 Mbps range. Upstream throughput improved over tenfold, to 122 Mbps, by using a more advanced modulation scheme.

DOCSIS 3 required significant upgrades to the cable operator's plant for an HFC network with fiber backhauls to handle all the extra traffic. However, by sticking with the 1GHz spectrum supported by existing on-premises coax cable and splitters, it didn't require consumers to do anything more than buy a new modem. That strategy of evolutionary, non-disruptive infrastructure is a key advantage over FTTX rip and replace that the cable industry is determined to keep exploiting.

DOCSIS 3.1 DETAILS

Increasing bandwidth without changing existing cable plants required inventing some complex technology as the benefits of channel bonding became tapped out. Although DOCSIS 3.0 can theoretically combine enough channels to reach gigabit speeds, since most cable systems only run up to 1GHz and are already full of HD and SD video channels, adding bandwidth would mean eliminating programming.

DOCSIS 3.1 solves this problem. The secret sauce is a new modulation scheme that eliminates the use of fixed 6MHz channels and instead splits the entire system spectrum into much smaller, 20kHz- to 50kHz-wide subcarriers that can be amalgamated into much larger blocks without moving existing digital video channels.

The magic technology behind this hyper-efficient spectrum usage in DOCSIS 3.1 is the switch to orthogonal frequency-division multiplexing (OFDM), a technique that trades the use of a single carrier frequency and channel for a large number of tightly spaced

ABI Research forecasts that there will be approximately 9 million broadband subscribers using DOCSIS 3.1 equipment by 2017, representing slightly more than 1 percent of total fixed broadband subscriptions worldwide.

subchannels. OFDM effectively parallelizes data transportation while providing great flexibility in how the subchannels are mixed and matched. Within each subchannel, the system still uses a QAM modulation scheme; however, DOCSIS 3.1 has several improvements over earlier versions. It uses a more complex, higher-order implementation spec (QAM-1024 or -4096); a more sophisticated error correction algorithm; and technology to eliminate channel guard bands. Together they provide about a 50 percent improvement in bit throughput per unit of bandwidth.

John Chapman, CTO of Cisco's cable access business unit, is leading the development of the DOCSIS 3.1 specification and said in an interview that this is a technology and product refresh for cable-delivered IP services.

"It advances the progression to full-spectrum technology, which gives service providers the ability to stripe IP services across the entire cable spectrum, over time," said Chapman. "And, it enables more bits per Hertz, on the wire — always good."

DOCSIS 3.1 also improves the responsiveness and user experience for gaming and other real-time applications by incorporating what's called active queue management (AQM). AQM is a QoS tool by another name in that it allows cable operators to prioritize packets and reduce network latency. It also provides control over cable modem buffers and queue depth that can further reduce overall transit time.

PHYSICAL REQUIREMENTS, MIGRATION AND ROAD MAP

The 3.1 standard manages all of these improvements while maintaining compatibility with DOCSIS 3.0 and earlier, which allows cable operators to upgrade their back-end infrastructures without disturbing the customer's premises wiring or equipment.

Customers will need new modems to take advantage of the technology. However, DOCSIS 3.1 modems are backward-compatible with 3.0, and there's an incentive for large customers to upgrade early because DOCSIS 3.1 supports a form of modem power management that cuts energy use during idle times.

In a nutshell, operators and customers can upgrade to DOCSIS 3.1 independently, which facilitates a gradual, seamless transition from old to new standards.

Although DOCSIS 3.1 is stable, with products already being certified and pilot tests underway (more on these follows), CableLabs has an exciting enhancement on the road map. Earlier this year, it announced plans for full-duplex DOCSIS with

Want to know more?

Check out a 60-minute webcast where Jorge Salinger from Comcast, Jeff Finkelstein from Cox Communications, Ayham Al-Banna from Arris and John Chapman from Cisco discuss:

- An overview of the DOCSIS 3.1 specification, including OFDM, MAC layer, downstream and upstream PHY, and forward error correction
- The transition from DOCSIS 3.0 to 3.1 and the timeline for deployments
- Equipment considerations

symmetrical up- and downlink bandwidth. Recall that DOCSIS 3.1 still uses separate sections of spectrum for upstream and downstream traffic, which yields asymmetric bandwidth. Although CableLabs offers few details, it hints at moving from frequency division multiplexing (FDM, the existing scheme with separate frequency bands for each direction) to time division multiplexing (TDM).

TDM is widely used in wireless networks (including Wi-Fi and GSM) and CableLabs hints at a similar approach in which the entire cable frequency range is available for time-sliced data traffic. It says the technology is capable of "up to 10 Gbps symmetrical on 1GHz HFC networks, with the potential for even higher performance by utilizing spectrum that is currently available for future expansion above 1GHz."

Nice to think about, but there's some skepticism. One analyst, for example, expressed suspicion that CableLabs unveiled the proposed fully symmetrical, multigigabit version early in the spec-crafting process as opposed to waiting for the more concrete R&D phase, which typically takes three to four years.

Our take: Whatever the time frame, symmetrical bandwidth is required for widespread adoption by business users, particularly those moving to cloud services, and to keep pace with fiber-based competitors. Cable companies need to keep up the pressure.

CERTIFICATIONS, PILOT TESTS AND DEPLOYMENT

2016 is the year DOCSIS 3.1 moves from standardization and development to certification and production. In January, CableLabs certified the first DOCSIS 3.1 cable modems, with products from five vendors successfully completing tests for standards compliance and interoperability. In order to accelerate future certifications, CableLabs has held a series of plug fests that allow manufacturers to collaborate on dry-run spec and interoperability tests before submitting products for formal review, with 27 vendors participating in events last year.

In December, the first cable operator started testing DOCSIS 3.1 in a live field trial. After upgrading its Philadelphia infrastructure, Comcast's 3.1 pilot required little more than a new on-premises modem and a software upgrade to neighborhood distribution hubs. The company continues to expand the Philadelphia pilot, including other trial deployments in Pennsylvania, Northern California and Atlanta.

Time Warner Cable is also preparing for DOCSIS 3.1. Last year the company responded to an RFP for a Los Angeles community broadband project, CityLinkLA, that requires providing "wire-line access to the Internet to homes and businesses (or to the curb outside a home or business combined with a wireless connection to the premises) via a network designed to deliver symmetrical speeds of 1 Gbps or higher to each residential unit, and to offer a business level of service at similar or higher speeds." TWC says that by using DOCSIS 3.1, it is "well-positioned to deliver residential Internet speeds of up to 1 Gigabit per second throughout our entire LA footprint — not just in a few neighborhoods." In 2014, the company completed an all-digital upgrade in L.A. that should make the 3.1 upgrade relatively straightforward.

Cox Communications is another operator getting ready to launch DOCSIS 3.1 field trials, with wide-scale deployment expected next year.

Related Reports

- Remote Site Slowdowns? 3 Last-Mile Fiber Fixes
- Build a Go-Fast Wan to Optimize Cloud Connections
- 8 Great Reasons Customers Should Go Big on Bandwidth
- Cablecos & The Channel: State of the Market 2015

As DOCSIS 3.1 moves from specification to product, the cable industry has taken a cue from the Wi-Fi business by creating a catchy brand name, Gigasphere, which will serve as the broad label for services that meet DOCSIS 3.1 specs. Buyers — whether consumers, channel partners or enterprise IT — should expect to see and look for this moniker when planning gigabit network up-grades, although operators will have separate branding for their own gigabit services.

PARTNER TO-DO LIST

We've previously advised partners (here and here) of the many options for WAN connections, and DOCSIS 3.1 ensures that cable broadband remains an important weapon in the enterprise WAN arsenal.

Although fiber connections with metro Ethernet or other carrier service are still an excellent option, it's not widely available outside urban cores and office parks. There's a good reason — laying fiber is expensive and time-consuming, as the slow rollout of consumer-grade services like Google Fiber and AT&T GigaPower attest. In contrast, DOCSIS 3.1 deployments using existing HFC plant should be much faster.

DOCSIS 3.1 delivers security advances, including a new public key infrastructure that strengthens the security of cable modem authentication, encrypted multicast, more secure provisioning and software downloads, and better state awareness.

Partners whose clients could benefit should press cable providers in their areas about gigabit upgrade plans, and advise customers needing a WAN speed boost to strongly consider cable over more expensive alternatives. Existing cable services already provide bandwidth of 100 to 300 Mbps, with DOCSIS 3.1 hitting the gigabit promised land within the next couple of years. Using cable for WAN connectivity allows partners to offer an order-of-magnitude range of performance from a single infrastructure. It's the kind of flexibility customers love and businesses with growing digital footprints demand.