Comparing Cable And Fiber Networks

Fiber networks are capable of sustained, symmetrical 100 Mbps service that cable networks cannot match.

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Cable broadband technology is currently the primary means of providing broadband data service to homes and businesses in most of the United States. Hybrid fiber-coaxial (HFC) cable networks will be the main pathway for broadband communications for most homes and businesses for the foreseeable future because of their ubiquity in populated areas and their inherently greater capacity than commercial wireless solutions and copper telephone lines (the medium underlying DSL service).

However, cable networks face significant and costly challenges to achieve the performance, capability and scalability afforded by fiber-to-the-premises (FTTP) networks.

Though cable operators widely offer download speeds of "up to 150 Mbps" over their HFC networks, they are unable to support these speeds on a sustained basis for a large percentage of customers simultaneously without significant upgrades to their networks. On the other hand, most current FTTP deployments can provide sustained speeds ranging from 100 Mbps to 1,000 Mbps at one time, to all customers, with the ability to scale network capacity exponentially with relatively minor upgrades. Depending on the technology used, FTTP can provide sustained symmetrical services at these speeds; most cable operators limit their residential service offerings to 20 Mbps or less in the upstream direction.

HOW DO CABLE SYSTEMS DELIVER DATA?

The delivery of Internet data services over traditional HFC cable television systems was standardized by a nonprofit research and development consortium, Cable Television Laboratories (CableLabs), and ratified by the International Telecommunication Union (ITU) under the name Data Over Cable Service Interface Specification (DOCSIS).

DOCSIS is the technical standard by which data communications can occur bidirectionally over a cable TV system. Like cable television services, DOCSIS uses separate channels within the radio frequency (RF) spectrum of the network cable plant. Traditionally, cable television channels each use 6 MHz of spectrum.

The latest deployed version of the standard, DOCSIS 3.0, enables combining,

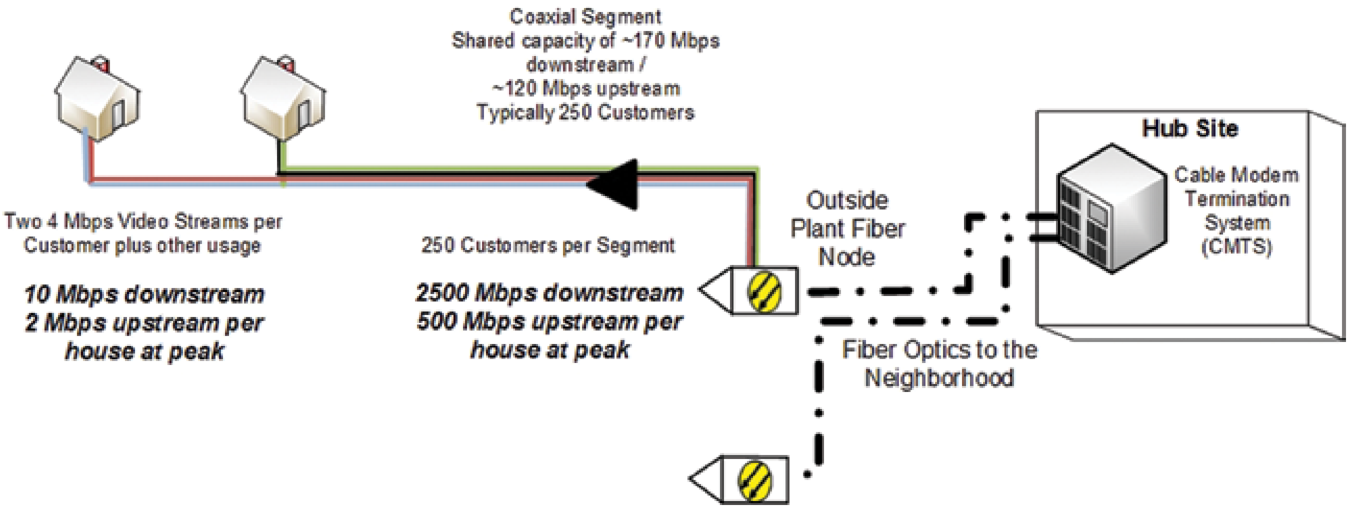

Figure 1: Sample DOCSIS 3.0 network

or "bonding," multiple channels, both downstream (from a provider to a customer) and upstream (from a customer to a provider). The DOCSIS 3.0 standard requires that cable modems bond at least four channels to achieve maximum connection speeds of approximately 170 Mbps downstream and 120 Mbps upstream. (Actual usable throughput is reduced by approximately 10 percent due to physical layer overhead related to error correction and coding.) A cable operator can carry more capacity by bonding more channels.

Ultimately, the maximum speed delivered over an HFC network is limited by the physics of the cable plant; although an HFC network has some fiber, the final connection to the customer uses coaxial cable. The coaxial portions of the network generally are limited to less than 1 GHz of usable spectrum in total (generally 860 MHz or 1 GHz in the most advanced networks). By comparison, the available capacity of fiber optic cable is in excess of 10,000 GHz –10,000 times greater – which allows for virtually limitless scalability into the future by simply upgrading the network electronics.

Figure 1 illustrates DOCSIS 3.0 network architecture in a four-channel configuration. In a DOCSIS 3.0 network, fiber optic connections enable the cable operator to connect each neighborhood separately to the system and the Internet, effectively segmenting the network. In a four-channel configuration, each segment has approximately 170 Mbps downstream and 120 Mbps upstream.

Figure 2 illustrates how this architecture quickly runs into limitations. In a peak usage period, a customer may, conservatively speaking, use 10 Mbps downstream and 2 Mbps upstream – a load that can be generated by two Netflix HDTV streams and uploads of photos, videos, iCloud synchronization and gaming.

Typical cable systems in our experience have 250 customers per segment, so the hypothetical demand per segment at peak time in this scenario is effectively 2.5 Gbps downstream and 500 Mbps upstream.

Cable operators manage the capacity by monitoring segment utilization and identifying areas where utilization exceeds certain thresholds. When an operator hits the threshold in a segment, it has two short-term options:

1. Add channel capacity to the DOCSIS cable modem network, potentially requiring the operator to modify video compression or reallocate video channels (this is possible by migrating channels to more efficient MPEG-4 compression, moving on-demand and less-frequently used channels to IP transmission over the DOCSIS cable modem network, or eliminating channels). Cable modems capable of supporting 32 downstream channels and eight upstream channels are now available, and the DOCSIS Modular CMTS (M-CMTS) architecture more readily allows for the use of additional channels.
2. Reduce the size of the segment by constructing additional fiber in the neighborhood or, if possible, segmenting the node (this is possible if the node sits at the juncture of two or more coaxial trunk cables).

One strategy might be to expand to 32 channels downstream, which would increase cable modem capacity to 1.04 Gbps downstream and 120 Mbps upstream per segment, and cut the segment size to 100 customers, which would reduce the hypothetical peak demand in the segment to 1 Gbps downstream and 200 Mbps upstream. This approach will temporarily fill the gap. As more applications and devices are introduced, however, cable operators will need to build fiber deeper into neighborhoods and closer to end users, free up more spectrum from television channels and introduce new technologies, such as DOCSIS 3.1, which can increase spectrum efficiency further.

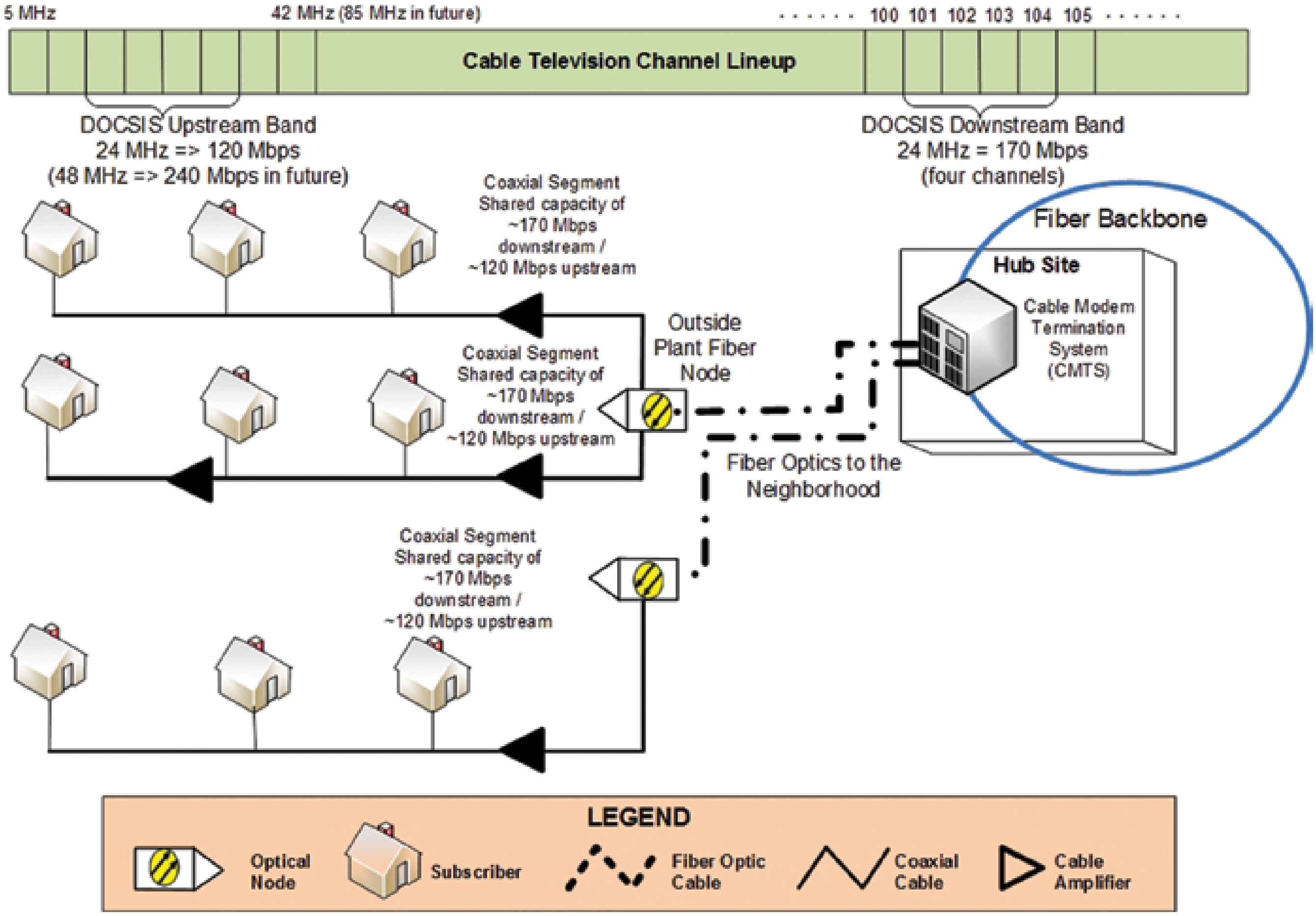

Figure 2: Illustration of DOCSIS peak usage scenario

These upgrades will obviously entail costs, though how much they will require above normal life cycle expenses is difficult to judge and will vary by provider. Gigabit speed will push the limits of the RF capacity of most cable systems (750 MHz, 860 MHz) and therefore require replacing the fiber node equipment, the RF amplifiers and, depending on the level of upgrade, possibly the active taps and subscriber drop cables. Some of these upgrades would occur as a matter of course, but some will represent extra costs for operators.

Similarly, upgrading to DOCSIS 3.1 would require replacing customers' modems and making some upgrades in the headend/hubs. Depending on how this is done, an operator would incur expenses ranging from $50 to $150 per subscriber, but much of this cost would be incurred anyway in regular equipment replacement. However, DOCSIS 3.1 is not completely backward-compatible with DOCSIS 3.0 and earlier versions, meaning that DOCSIS 3.0 cable modems cannot use DOCSIS 3.1 channels. Thus, a cable operator may need to allocate non-overlapping channel space for both technologies for at least some migration period if it intends to fully leverage the capacity advantages of DOCSIS 3.1; this would further drive the need for expensive field upgrades of active and passive RF components to increase the bandwidth of the coaxial portions of the HFC network.

DON'T CABLE OPERATORS OFFER 150 MBPS SERVICE ALREADY?

Certain cable operators, including Comcast and Cox, offer "up to" 150 Mbps as a peak speed at the top end of their service offering. It is not guaranteed as a minimum speed available at all times (or at any one time). Few customers will reach 150 Mbps other than as part of a speed test or possibly when transferring large files from online storage services. In offering "up to" 150 Mbps, cable operators bet that only a small fraction of users will use this speed at the same time and that they will not really have to deliver the advertised speed to most customers or on a sustained basis.

Further, these cable operators face no penalty if a user tries for 150 Mbps during a busy peak time and can attain only 60 or 80 Mbps, because 150 Mbps is offered only as a maximum, aspirational speed. Therefore, it is possible to offer "up to" 150 Mbps service when only 1 Gbps is available to be shared among 100 or more customers.

Significantly, these 150 Mbps offerings provide only 20 Mbps upstream as a result of the cable companies' upstream spectrum limitations.

The high-speed offerings of FTTP providers are driving cable operators to attempt to keep pace over their existing HFC networks by pushing the limits of their cable modem systems. Time Warner Cable, for example, offers 300 Mbps in some markets by utilizing DOCSIS 3.0 with 16 downstream bonded channels. This provides theoretical maximum connection speeds of up to 600 Mbps. Suddenlink recently announced a plan to offer a 1 Gbps service tier. Although technical details have not been revealed, the company reportedly plans to upgrade all cable modems to DOCSIS 3.0 as part of its Operation GigaSpeed and will make the service available to nearly all customers.[1] These details suggest a plan to leverage DOCSIS 3.0 in a 32 (or greater) downstream channel configuration or potentially to migrate to DOCSIS 3.1 with both DOCSIS 3.0 and 3.1 coexisting. A plan to deploy FTTP would likely cost much more than the $230 million that Suddenlink plans to invest in this initiative over the next two years to reach its entire customer base.

Cable companies will not be able to sustain either 150 Mbps or any higher speeds over HFC networks once Web content capable of utilizing these connection speeds becomes more widely available and once video streaming, video communications, games and multimedia begin to use that type of capacity on a constant, continuous basis. The use of online file sharing and other cloud-based services (Google Drive, Dropbox, Microsoft Office 365, etc.) will continue to drive the need for connection speeds comparable to those of local area networks, with ever-increasing amounts of data being constantly transferred over the Internet rather than staying local to customers' devices.

> Cable offerings of 150 Mbps and higher are possible only because few people use them on a sustained basis. They will fail as Web usage becomes more intensive.

As these trends continue, cable operators will need to upgrade their systems and use technologies such as DOCSIS 3.1 or make more fundamental architecture changes such as constructing fiber deeper into neighborhoods and employing Distributed Converged Cable Access Platform – or both.[2]

Perhaps an indicator of the practical speed limit for current HFC networks is Comcast's most recent response to the ongoing leapfrogging of speed increases among competing providers. The "Extreme 505" service tier provides 505 Mbps downstream and 100 Mbps upstream and is deployed using FTTP – the same technology Comcast uses to provide its business-class Metro Ethernet services.

FTTP CAN DELIVER A DEDICATED, SUSTAINED, SYMMETRICAL 100 MBPS

Fiber has a much greater spectrum than coaxial cable, and FTTP networks therefore eliminate one of the most significant bottlenecks in a cable system. Off-the-shelf FTTP equipment delivers 1 Gbps symmetrical services to each customer over a single fiber. Meanwhile, 10 Gbps equipment is widely available and falling in cost.

Some FTTP operators, such as Verizon FiOS, use passive optical network (PON) technology, typically splitting the fiber capacity in a neighborhood cabinet to connect 16 to 32 customers. These provide less capacity than the direct fiber networks (also known as active Ethernet or point-to-point) but are still generally able to sustain a constant 100 Mbps to all users in the downstream direction simultaneously; indeed, given that most customers' consumption of capacity today is highly variable and that some degree of oversubscription is reasonable in any network, it is reasonable to expect that symmetrical connections of 1 Gbps capacity can be supported today over most PON networks with much less oversubscription of access network capacity than in DOCSIS networks. Currently deployed PON networks have capacity of 2.5 Gbps/1.2 Gbps (GPON) or 10 Gbps/2.5 Gbps (10G-PON), which can provide between about 75 Mbps and 300 Mbps of "dedicated" capacity per customer even with a splitter ratio of 1:32.

Finally, the upgrade path for a fiber network is simpler and usually cheaper than for a cable network. This is because a speed upgrade usually involves only replacement of electronics at the central office hub and the customer premises; a cable speed upgrade requires replacement of electronics, construction of new fiber and upgrade of coaxial cable and components. ❖

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ENDNOTES

1 www.multichannel.com/news/news-articles/suddenlink-unveils-operation-gigaspeed/383058

2 A detailed analysis of the likely upgrade path for cable systems is available at www.ctcnet.us/publications/the-state-of-the-art-and-evolution-of-cable-television-and-broadband-technology/