Solving the DAA Capacity Crunch with Packet Optical Transport

A Look at Optical Transport Solutions for Distributed Cable/MSO Networks

16 October 2018

Heidi Adams
Senior Research Director,
IP & Optical Networks
Technology, Media and Telecom

IHS Markit Technology

Contents

Introduction

Broadband services are the revenue growth engine for cable operators worldwide. In a highly competitive environment where subscriber retention and growth is absolutely critical, cable operators must continue to invest in their access infrastructure to increase speeds and improve the efficiency of their services. Moving forward, DOCSIS 3.1 and Full Duplex DOCSIS 3.1 (FDX) provide an evolution path to deliver 1G and higher services to the home by leveraging existing coax access infrastructure. The introduction of virtualization in the cable headend, fiber deep initiatives, and distributed access architectures (DAA) are all tools for cable operators to improve the capabilities and economics of delivering these new broadband services.

The combination of fiber deep (bringing fiber closer to the end-user) and DAA (performing analog to digital conversion farther out in the network) is driving a new investment cycle in cable operator aggregation and metro networks. The shift from analog optics to digital optics from the cable access node as well as a move from 1G to 10G in the aggregation network opens up a significant new opportunity for cable network–optimized WDM transport solutions. This paper explores the impact of DAA on cable access network infrastructure and the resulting opportunity for coherent packet optical transport solutions in support of this transition.

Market trends in cable access

The popularity of on-demand video and streaming video services has fundamentally changed how video content is consumed and has been the main driver behind consumer demand for faster broadband access services. For cable and multi-system operators (MSOs) that have traditionally garnered a significant portion of revenue from broadcast and pay TV services, High Speed Internet (HSI) services are now a critical revenue stream. In the European market, cable-based HSI services represented 34% of cable revenue in 2017, up from 28% in 2012 (IHS Markit). In the North American market, cable is even more broadly adopted with 63% of all wireline broadband subscriptions in 4Q17 based on cable, increasing from 61% in 4Q16. Cable broadband subscriptions were close to double DSL subscriptions in the same period.

Competition in the broadband access market is fierce with cable companies facing increasing telco-based fiber to the home (FTTH) services and a coming wave of 5G fixed wireless access services. Access speed and video quality are key metrics for retaining subscribers and attracting new customers. With the introduction of DOCSIS 3.1 standards to support the delivery of up to 10G services over HFC infrastructure, cable operators will be better positioned to effectively compete against FTTH services.

However, the introduction of higher and higher speed residential broadband services has put significant strain on cable operator access networks. Traditional strategies including splitting cable access nodes to provide higher speed services to subscribers are becoming increasingly expensive to implement and to operate. Bringing fiber closer to the customer (fiber deep) and distributing some of the functions traditionally performed at headend sites out to the access nodes provides an alternate path to cable access network evolution.

Cable access infrastructure evolution

Background

The idea of distributing headend or hub site network elements closer to subscribers has been around for a number of years. Beginning with the M-CMTS architecture (M for modular), as defined by CableLabs in 2005, separation of the MAC and PHY elements of a CMTS was proposed primarily to help reduce overall system cost, but it also sought to provide cable operators with architectural flexibility in the location of their network elements. Now, with cable operators looking at ways to improve the efficiency of their HFC networks while increasing the amount of bandwidth they can provide through node segmentation or upgrading, moving to a DAA becomes a potentially critical tool in improving the overall efficiency of their HFC plant.

Historically, the forward path (downstream) in HFC networks has used analog optics while the reverse path (upstream) has used a mix of analog and digital. Moving to digital optics becomes part of the equation when cable operators are weighing the costs of segmenting or splitting their optical nodes. The average HFC architecture today is “node + 5,” meaning an optical node followed by five separate amplifiers. Under current centralized architectures, cable operators can segment their nodes to reduce service group sizes, which in turn provides significantly more bandwidth per end user. Node + 1 or even node + 0 (FTTH) architectures are possible under this architectural approach.

However, with each node segmentation comes the added cost of new nodes, more analog optical lasers and receivers in the headend, and more CMTS channels. For many operators, a transition to lower cost digital optics and distributed access makes more sense than continuing down the path of continued node segmentation and splitting while still relying on analog optics, which have distance limitations.

Distributed access, which involves placing the PHY (analog to digital conversion) or the MAC and PHY (adding DOCSIS termination) access layer functions into the optical access node, can provide benefits when compared with traditional node segmentation and splitting:

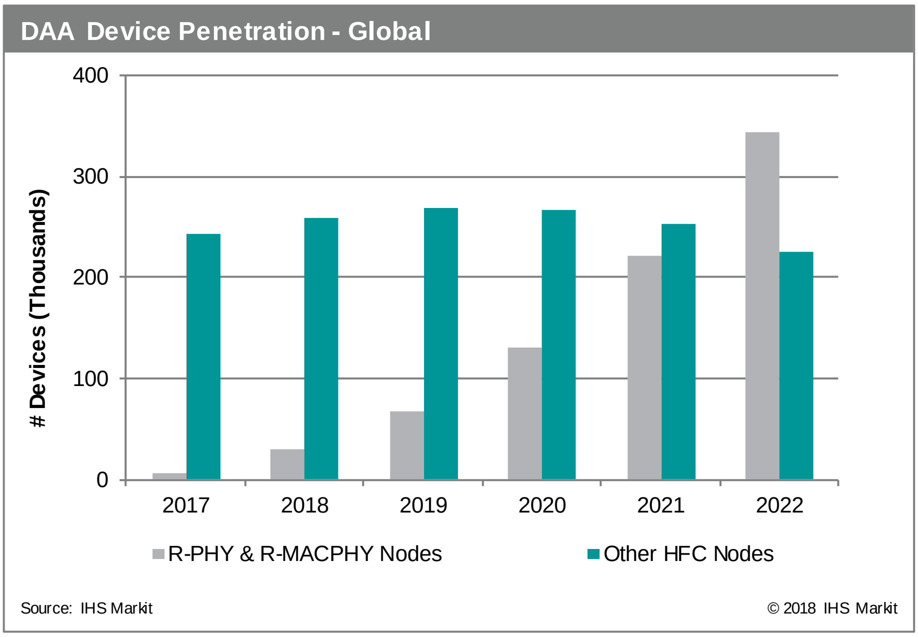
- Lower cost, commodity digital optics using Ethernet
- Ability to support longer distance fiber spans
- Ability to support more wavelengths per span
- Higher throughput for DOCSIS 3.1 services

By distributing either the PHY or MAC and PHY access layers and moving RF modulation further downstream, cable operators can reduce the total cost of the HFC plant by moving to Ethernet-based transport in the fiber portion. There are also some cost, space, and power advantages at the main hub site as PHY layer processing of CCAP/CMTS equipment is moved out to the access node and as racks of physical analog cable can be eliminated.

DAA momentum ahead

Although the benefits of moving to DAA are now widely accepted, the transition to DAA is only just getting started. Access equipment vendors including Arris, Cisco, CASA Systems, and Nokia/Gainspeed have brought R-PHY devices to market. Cisco claims to be working with over 60 cable operators worldwide on DAA plans, Casa Systems claims over 40 field trials, and Nokia indicates engagements with cable operators in all regions. The question is no longer if DAA will be deployed but when.

In the US market, Comcast has indicated plans to introduce DAA nodes and Full Duplex DOCSIS later this year. Cox Communications is implementing fiber deep and indicated a 2018 timeframe for the start of DAA deployments. The market is just starting to get underway. As shown in the next exhibit, IHS Markit predicts that by 2022, close to 50% of access nodes sold will support DAA implementations.

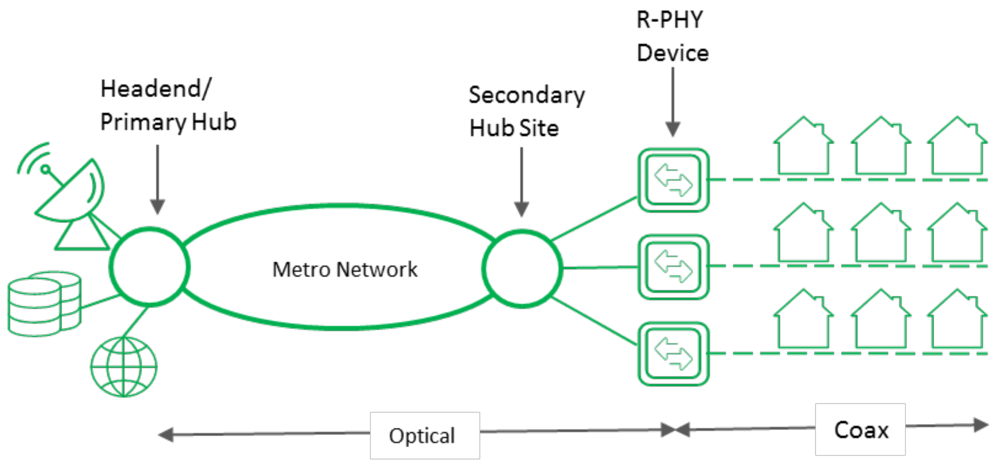


Modernizing cable aggregation and transport networks for DAA

With the implementation of DAA and the shift from analog to digital optical connections between the cable head/primary hub location and the RPD, cable companies have the opportunity to revisit the design of their metro aggregation and transport networks to take advantage of newer direct-detect and coherent optical technologies. For connectivity speeds in excess of 10G, coherent optical solutions bring the benefits of higher capacity channels (wavelengths), longer reaches, and tight integration with DWDM systems. Recent advances in coherent DSP technology are at the center of a new range of metro-oriented optical transport solutions addressing the capacity, space, power, and price point requirements of the metro aggregation market.

To explore how digital optical technology including direct-detect (non-coherent) and coherent optics can play in distributed cable access architectures, we will consider a simple reference architecture with RPDs connected directly to secondary hubs, which are then aggregated up to the headend/primary hub sites where CCAP equipment is located. Note this is for illustration purposes only—cable networks will vary based on service speed, service group size, subscriber density, and total overall subscribers served.

Reference Architecture for DAA Aggregation and Metro Core Networks



Source: IHS Markit

Connecting R-PHY devices to the network

Typical cable access networks in the US may see 500 or more homes connected per access node (a service group). Amplifier chains are used to extend the reach of the coax plant to each home. Fiber deep initiatives bring the access node closer to the home, in effect reducing the service group size by an order of magnitude and, if deep enough, eliminating the need for amplifiers between the node and the end customer. With DAA, and in particular with Remote-PHY devices (RPD), the analog to digital signal conversion happens in the access node. For access networks designed to support DOCSIS 3.1 services, the uplink from the RPD is typically a 10GbE connection.

Although the access node gets closer to the home, it also gets farther away from the hub site it must connect to. Distances greater than 10 km are common and may extend to 40 km or more in some instances. Grey optics can be used when dedicated fiber is available. Colored optics provide the advantage of being combined using CWDM or DWDM to support multiple 10G channels over a single fiber pair. The need to manage a large number of colored optics at different frequencies has led to the development of tunable optics, which are today the current standard for 10G optical transport. When considering the emerging DAA market, the need for solutions that can further facilitate the installation and commissioning of RPDs is critical. Even tunable optics require additional tracking and management of frequencies. “Colorless” or “auto-tunable” optics that can be remotely configured to transmit over different colors or frequencies are a new approach to 10G transport that facilitates the deployment process, especially when many, many end points must be deployed and coordinated. Techniques including auto-discovery and zero touch provisioning reduce the time and cost required to set up and maintain these devices in the field.

Connecting secondary hub sites to headend sites

At the secondary hub site location, 10GbE RPD connections are aggregated for transport to the primary hub site where CMTS/CCAP equipment is located and DOCSIS services are terminated. There are several challenges to be addressed at this network location:

- **The sheer volume of traffic:** In centralized architectures, 60+ HFC nodes might be aggregated at a given secondary hub site. Assuming 10 RPDs in place of each HFC node with DAA, secondary hub sites could be easily required to aggregate 600 or more RPDs each with a 10GbE connection. Without redundancy factored in, this can easily equate to 6 Tbps of traffic per site.

- **Distance to the cable headend site:** With cable operators typically deploying 1–2 cable headend sites per metro area, the distance between secondary hub sites and cable headend sites could easily exceed 100 km—much of this in the routing of the fiber infrastructure. Solutions must be able to efficiently transport over metro reaches.

- **Space and power:** With limited space and power availability in distribution sites, secondary hub site equipment must be compact and power efficient.

- **Delivery of other services:** Enterprise and cell tower backhaul services are also key growth areas for cable companies. The ability to leverage metro aggregation network investment to also enhance these services can be an important aspect of the solution design and the business case for investment.

Equipment solutions for secondary hub sites will include a combination of high-density Ethernet switching for 10GbE to 100GbE aggregation and optical transponder platforms that convert 100GbE to high-capacity wavelengths for transport across the metro aggregation network. Optical transport platforms that were initially designed for the web-scale Internet content provider (ICP) market for data center interconnect (DCI) are also a very good fit for the requirements of the cable secondary hub site. By design, they are compact 1–2RU stackable and power efficient devices that typically support 200G to 400G wavelengths for metro optical applications today with plans to support 400G–600G wavelengths in the late 2018 or early 2019 timeframe. These systems are complemented by compact DWDM line systems and ROADMs (Reconfigurable Optical Add Drop Multiplexers) that efficiently combine and route wavelengths to the cable headend.

Evolution at the cable headend location

The move from 1G to 10G in the access network and 10G to 100G in the aggregation network results in a huge volume of traffic to be managed at the cable headend site. Spine-leaf network architectures implemented within the headend site and extended to secondary hub sites are being explored as a way to more efficiently manage traffic, handle resiliency, and provide a framework for future capacity expansion.

As CCAP/CMTS and broadband router functionality (subscriber management, VoIP, and other services) in the headend become virtualized and deployed on general purpose compute platforms, the headend site begins to look increasingly like a data center location. The concept of the head end re-architected as a data center (HERD) follows principles similar to the central office re-architected as a data center (CORD) vision, where many of the functions performed at these locations are virtualized and new approaches to application and service orchestration emerge. From a network equipment infrastructure perspective, support for open data models and a range of open APIs to interface with northbound control and orchestration applications become baseline requirements for operating in this new environment.

Conclusion

The combination of fiber deep and DAA will drive a major new investment cycle in cable operator access, aggregation, and metro networks. The shift from analog optics to digital optics from the cable access node and the move from 1G to 10G in the cable access network and from 10G to 100G in the metro aggregation network open up a significant opportunity for a new generation of cable network–optimized coherent optical transport solutions.

Contacts

Heidi Adams
Senior Research Director,
IP & Optical Networks
+1 408-583-3388
Heidi.Adams@ihsmarkit.com

IHS Markit Customer Care:

CustomerCare@ihsmarkit.com
Americas: +1 800 IHS CARE (+1 800 447 2273)
Europe, Middle East, and Africa: +44 (0) 1344 328 300
Asia and the Pacific Rim: +604 291 3600