MODERNIZING THE CABLE SERVICE DELIVERY INFRASTRUCTURE

Sponsored by ARRIS (now part of CommScope)

EXECUTIVE SUMMARY

Market forces and the insatiable demand for bandwidth, both upstream and downstream, are driving cable operators to modernize their network infrastructure and operations. Many technologies and operational improvements are available to them in the short and longer term to support this end. Operators today are increasing the average capacity per subscriber by reducing the size of their service groups whenever they pull fiber closer to the subscriber. Operators are also expanding the total capacity offered within their networks by increasing the width of the useable RF spectrum inside their HFC plants. In addition, they are looking to replace analog fiber with digital fiber for better transmission characteristics and better reliability. Some operators are also planning to consolidate their headends and hubs to reduce operational complexity and cost. At the same time, technological innovation is providing new directions, of which some of the most impactful are the Distributed Access Architecture (DAA), Virtualization, Full Duplex DOCSIS (FDX), and Extended Spectrum DOCSIS (ESD).

The DAA presents two options: moving the PHY layer to the node in the access network (Remote PHY or R-PHY or RPD) or moving both the PHY and MAC to the node (Remove MACPHY or R-MACPHY or RMD). Each option has advantages and tradeoffs. For example, R-PHY requires less power in the outside plant and permits re-use of already-deployed DOCSIS MAC processing while R-MACPHY requires less power in the headend and typically delivers lower latency transport to subscribers. Furthermore, in the R-PHY case, the CCAP core, which remains in the headend, can run on the traditional CCAP chassis or can become virtualized and run on COTS servers in a cloud-based data center.

DAA is not the only option for the future. For some operators, at least in some markets, a dense, Integrated CCAP (I-CCAP) remains the most economical and appropriate solution; while in other areas where fiber needs to be connected to the subscriber premises, a Remote OLT (R-OLT) solution is more suitable. Furthermore, for some operators, FDX and/or ESD will be utilized to deliver the bandwidth capacity that is required. Operators that choose the DAA or OLT architectures can ultimately reap the benefits of virtualization, which may include feature velocity, elastic capacity, less reliance on purpose-built hardware, and ultimately lower costs and an improved customer experience.

To select the solution that best suits their networks, operators need to carefully consider a number of operation and business-related parameters. Operators' needs will likely change over time, and the architecture they select today may not be optimal in the future. Therefore, it behoves them to work with a vendor that brings a broad range of market-tested solutions. The vendor must have a full suite of network management, comprehensive customer support solutions, and work closely with the operator to help evolve its architectures when the need arises.

INTRODUCTION

New entrants, shifting market dynamics, new customers' behaviors and expectations are disrupting the cable industry. Operators are increasingly seeking new revenue sources with a focus on the business market and on offering new services, such as wireless. Their infrastructure is under increasing strain from the ever-growing demand for bandwidth to enable streaming and other services. Cable infrastructure if left unmodified will be unable to meet the growing demands of the marketplace, and the short-term strategies operators are pursuing will not be sustainable in the foreseeable future. Therefore, operators have embarked on a far-reaching transformation of their networks and businesses to meet the needs of a changing and highly competitive market and to grow their top-line revenue. Essentially, they are seeking to become comprehensive communications service providers that can offer all of the services and experiences that their customers demand.

A major element of this transformation is the network, which for the most part is analog, rigid, and difficult to scale in its current form. It also restricts them to a limited talent pool for network management, thus leading to higher costs. A careful, well-planned transformation of their networks and business environments will position cable operators on a strong competitive footing for decades to come.

THE STATE OF THE CABLE INDUSTRY

The cable industry is undergoing a significant transformation. Its traditional video business is declining as customers increasingly gravitate to streaming, new content aggregation models emerge, and as online video consumption and improving video quality (4K and eventually 8K) are leading to an exponential growth in bandwidth consumption.

Declining legacy business

Cable operators continue to lose video subscribers on a quarterly basis. In 4Q 2018, top US cable operators lost 243 thousand video subscribers and more than 900 thousand total subscribers. This decline is driven by changing customer behaviors and expectations and by developing competitive dynamics.

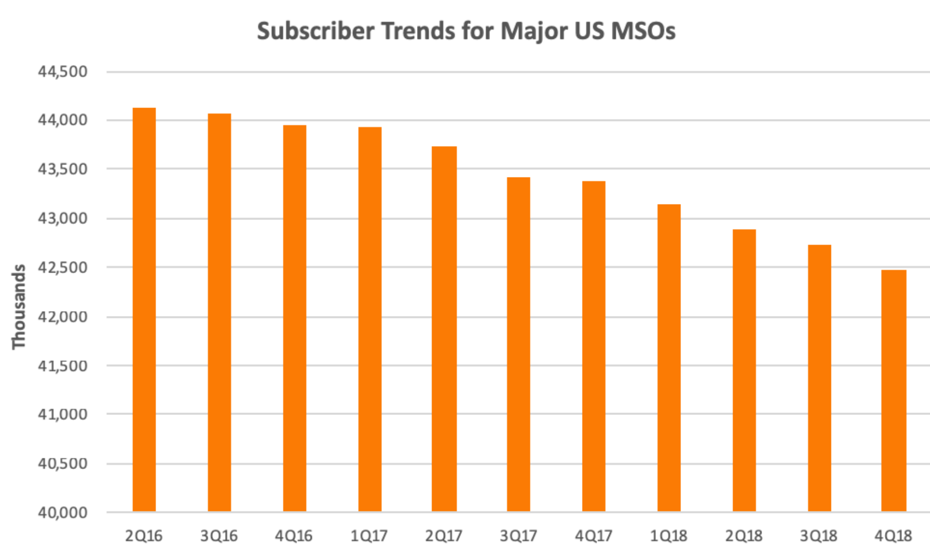

Figure 1. Video Subscriber Trends for Major US MSOs (Source: Company Data)

At the same time, the trend toward video streaming and other bandwidth-hungry applications is leading to greater bandwidth consumption in both the downstream and upstream. The five-year CAGR for upstream has been increasing, and some operators are seeing significant jumps in upstream traffic in recent years. Figure 2 shows actual data measured by a number of MSOs[1].

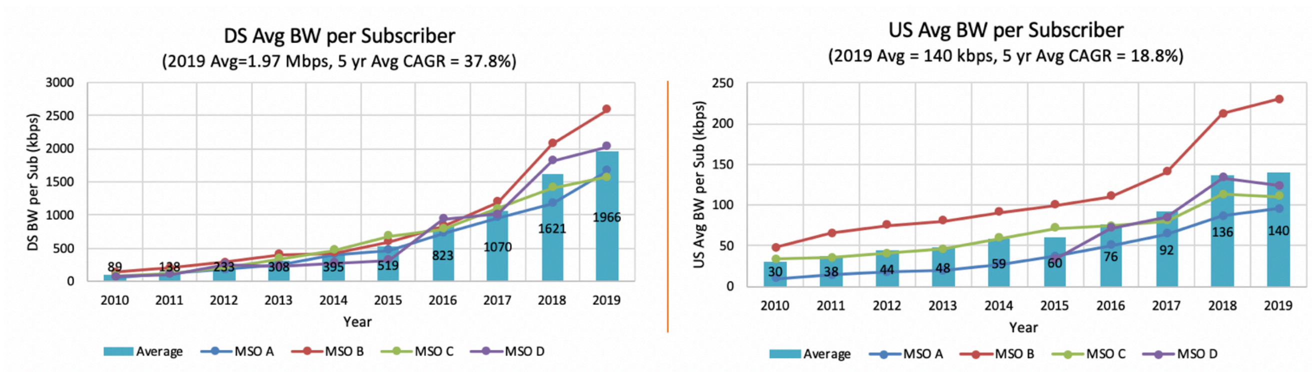

Figure 2. DS and US Peak Busy Hour Subscriber Bandwidth Consumption (Source: CommScope)

These market realities are driving cable operators to seek new revenue opportunities, to augment network capacity, and to evolve their infrastructures and business models as their business shifts away from legacy service, making their legacy infrastructure incompatible for the delivery models the market demands. Cable operators will be well-positioned in the future provided they evolve their plants and their operating environments to better align with the requirements of the new services.

CONSIDERATIONS FOR MODERNIZING THE CABLE NETWORK INFRASTRUCTURE

Cable operators are pursuing a number of strategies to improve their network infrastructures and lower their costs.

Reduction in service group size to meet bandwidth demand

To improve signal quality and increase bandwidth capacity per subscriber, cable operators are pushing fiber deeper into their access networks and reducing service group sizes; they are also growing total bandwidth capacity with spectral increases and transitions to higher-order OFDM QAMs within the HFC plant. Traditionally, a service group might serve 500 subscribers on average and sometimes as many as 1,000 subscribers. Some operators are aiming to reduce the size of the service group to as low as 50 subscribers. At the same time, they are looking to substantially reduce the number of amplifiers between the access node and the subscribers. Today, some operators have as many as 10 (typically 4) amplifiers between the node and the subscribers, which introduce signal degradation and hamper the operators' efforts to augment the return path by taking advantage of future technologies, such as Full Duplex DOCSIS (FDX). Some operators, notably Comcast, have committed to reducing the number of amplifiers to zero in

[1] Data is provided in January for every year.

what is referred to as N+0; however, in some locations, N+0 might be cost prohibitive, and some operators are considering N+1 or slightly larger N+X systems (X>0); what they call N+small.

The reduction in service group size is leading to a significant increase in the number of nodes, often by a factor of 8 or even 12. The increase in the number of nodes will require a significant expansion in the number of fiber optic wavelengths to connect the new nodes. It will also require longer fiber runs, because the nodes are deeper in the access network and thus farther from the headends and hubs. In many cases, the existing analog optics do not have enough wavelength capacity to source the additional nodes. They also have distance limitations, leading operators to consider replacing analog optics with digital optics. Digital optics support more wavelengths on the fiber (36–72 for digital optics versus 16–32 for AM optics). Furthermore, the proliferation of nodes increases the complexity of managing the access network, leading operators to seek new cloud-native automation tools.

Facilities consolidation

Cable operators have a significant number of hubs and headends in their networks. Some of the hub sites are small and serve as little as 50 nodes, essentially the size of a CMTS. Some of these hubs were created because of the distance limitations and capacity constraints of the analog fiber. With the higher capacity and longer distances possible with digital fiber, these hub sites and some headends can be consolidated, which results in significant cost savings and operational simplification for operators. Facilities consolidation combined with long digital fiber runs to enable fiber-deep penetration will also set the stage for an eventual migration to FTTx should operators decide that FTTx is needed.

Fiber deep

The reduction in service group size is part of the strategy to bring fiber deeper in the access network. Today, the goal for operators supporting N+0 operation is to bring fiber to within 1000 feet of the home. For the customer that needs more capacity, fiber can be pulled all the way to the premises in a success-based FTTH PON or RF over Glass scenario, which is much more cost-effective to deploy than FTTH everywhere. It is possible that eventually the entire access network will move to FTTH, but this scenario is likely a decade or more away. In the near future, blended networks that include DOCSIS and PON will be most efficient for meeting market demand for capacity and cost-effectiveness. A major advantage for cable operators is the availability of power in their access network. Only five years ago, FTTH deployments, such as FiOS, relied on passive PON. Cable operators with power at the edge of the network can create or activate optical networks, enabling greater capacity. The availability of power within their networks (PON or HFC) may also permit cable operators to offer other future services that will require power closer to the homes, such as Edge Computing services or 5G Wireless Baseband Unit support services or WIFI Access Point support services.

Set and forget operational simplification

Today's cable network analog infrastructure can be expensive to operate and maintain. Analog fiber is sensitive to environmental factors and degrades over distances; it also requires specialized skills, typically gained over years of experience. Because of its analog- and hardware-based nature, the plant lacks monitoring capability and self-service functionality to customers. For example, in the fiber nodes, "health-checks" can only be performed every few minutes.

Conversely, in a digital environment, those checks can be performed every few seconds and faults can be detected much faster. A digital environment enables a self-monitoring, self-healing network environment where performance data is collected, analyzed, and potential degradation patterns are detected and remediated before they escalate into a full-blown outage. Operators need a more automated, data-driven, digital infrastructure that enables them to reduce their operating costs and offer their customers a true digital experience.

Improved signal quality

The current analog-based infrastructure is prone to signal degradation, which happens in the analog fiber, particularly as the distance and number of optical wavelengths increases. Degradation is somewhat exacerbated by the amplifier cascade between the node and the subscriber. Digital modulation is much more resilient due to its inherent error correcting capabilities: it reduces the impact of nonlinear noise, increases SNR, and permits higher spectral efficiencies with higher QAM orders. Furthermore, by pushing fiber deeper in the network, the amplifier cascade is either eliminated entirely or significantly reduced, which further improves the quality of the signal going to the customer's premises. This leads to better customer satisfaction and a significant reduction in truck rolls.

Migration from an older version of DOCSIS

Some cable operators are still using an older version of DOCSIS, such as DOCSIS 2.0. As they plan their migration to DOCSIS 3.0 or 3.1, they must revamp their network infrastructures to meet their future needs.

Enabling feature velocity

The traditional process for introducing new services, which relied on long development cycles, often depended on vendors' updates and sometimes on hardware changes. The approach is no longer a long-term, sustainable plan. Instead, operators need quick development, market introduction cycles, the ability to iterate and add features on a continuous basis.

Virtualization brings the flexibility and dynamic iteration capability that operators need; by instantiating capabilities as micro-services, operators can modify or augment services on a micro-level without the need to regression test the entire solution (as is now the case). This significantly shortens the cycle for development and field introduction.

Elastic capacity

The customized, hardware-based appliances that have been used by cable operators for many years offered solutions that were fine-tuned to efficiently perform the exact functions requested by the cable operators. A customized, hardware-based appliance will likely have higher performance and better power efficiencies than a similar software-based solution running on servers. As a result, that finely-tuned, hardware-based approach to delivering power-efficient solutions is still useful in the environment today and will undoubtedly be useful in the future as well.

However, another approach to delivering solutions has also become quite popular. For many operators, a software-based virtualized solution that runs on COTS servers may be easier to scale than a hardware-based equivalent.

With the virtualized solutions, software licenses can be easily purchased in response to increased market demand, and the software would be dynamically launched on available COTS servers within the data center. Leasing compute resources on servers within a public cloud provider is also feasible. These approaches may offer quicker and simpler ways to expand capacity than would be possible with the purchase of new hardware-based equipment.

In addition, the use of COTS servers permits a form of elasticity. The servers may be dedicated to MAC layer processing of subscribers' data traffic during the heavy usage broadband periods, for example during the later evening, but many of those COTS server resources can be freed up from MAC processing duties during the rest of the day. They can then be re-purposed for other processing applications at those times. This benefit is not typically permissible with hardware-based appliances.

Digital customer experience

Traditional customer service capabilities are no longer sufficient to meet the needs of customers that increasingly expect digital-based interaction to complement other forms of customer service. To deliver a digital customer experience, operators must modernize their legacy, hardware-based service delivery and management infrastructures.

New services

Cable operators are increasingly seeking revenue from new services as their legacy business matures. Business services have been a significant area of growth for most operators (for example, Comcast generated 13% of its revenue from business services in 4Q 2018 compared to 8.5% in 1Q 2014).

5G presents significant revenue opportunities for cable operators along many dimensions. Their access to subscribers' premises, their presence in the local communities, their "feet in the street" field workforce, and a power plant at the edge of the network and at the customers' premises make them uniquely positioned for the deployment and backhaul or fronthaul of 5G. Backhaul/Fronthaul of 5G small cell traffic is a particularly bright opportunity for cable operators, but one that depends upon digital fiber connectivity; 5G backhaul/fronthaul also requires upgrades to DOCSIS to support high-accuracy clocking and timing distribution, a capability on which the industry is diligently working.

These services demand capacity, flexibility, new capabilities, and an operating environment for which current plants are ill-equipped, but with the right architecture and operating changes, operators can evolve their HFC plants to become competitive players in the marketplace.

TECHNOLOGIES ENABLING NETWORK MODERNIZATION

As operators seek to modernize their networks, they have a number of new technologies to consider.

Distributed Access Architecture (DAA)

The DAA was developed by CableLabs and the cable industry to modernize the cable access network; it enables moving functions and elements that have been an integral part of the CCAP to the access network. This enables reductions in headend power and rack-space requirements, permits the headend environment to be virtualized over the long term, and leads to significant benefits for cable operators.

A valuable partner to DAA is DOCSIS 3.1, which enables a higher modulation order from the traditional maximum of 256 QAM modulation to 1,024 QAM (even 4,096 QAM) and results in throughputs of up to

10 Gb/s in the downstream and 1 Gb/s in the upstream. DOCSIS 3.1 capacity can increase to 5 Gb/s symmetrical service with Full Duplex DOCSIS (FDX), and future modifications may even provide 10 Gb/s symmetrical service. Extended Spectrum DOCSIS (ESD) is another technology that can substantially increase the symmetrical (or asymmetrical) capabilities of DOCSIS to even higher capacity levels.

There are two main variants of DAA:

- **Remote PHY or R-PHY:** The physical layer (PHY) is moved from the CCAP to the fiber node. A Remote PHY Device (RPD) is added to the node to handle the PHY capability. R-PHY is based on the MHAV2 CableLabs specifications.
- **Remote MACPHY or R-MACPHY:** The Media Access Control (MAC) and the PHY layers are moved to the fiber node. A Remote MACPHY Device (RMD) is added to the node, which handles the MAC and PHY capabilities[2].

Full Duplex DOCSIS

Today, the capacity delivered to the subscriber is asymmetrical. With DOCSIS 3.1, the maximum capacity is 10 Gb/s downstream and 1.5 Gb/s upstream. New services, such as video sharing, gaming, virtual reality, IoT, and 5G wireless backhaul, necessitate higher upstream bandwidth. According to CommScope, average upstream bandwidth use is accelerating 25–30% per year. One of the industry's answers to more upstream capacity is Full Duplex DOCSIS (FDX), which enables shared ~5 Gb/s transmission capabilities in the upstream by permitting simultaneous upstream and downstream transmissions within the FDX Frequency Band from 108-684 MHz in its most fundamental form, FDX likely requires an N+0 architecture. This is why some operators have committed to N+0 in most of their footprint for the future; however, given the complexity and cost of N+0 deployments, the industry is also working on other alternatives. One alternative is the use of an FDX capable amplifier. Research into FDX amplifiers is currently an active effort, and its final outputs are still uncertain. FDX is not expected to be deployed before 2020, but some FDX capable nodes are already being used in early field trials.

Extended Spectrum DOCSIS (ESD)

DOCSIS 3.1 will enable capacity up to ~10 Gb/s downstream and ~1.5 Gb/s upstream. FDX will enable a blended capacity of 10 Gb/s downstream and 5 Gb/s upstream. However, it is expected that the needs of the industry will exceed this capacity, and there is already preliminary work on designs to enable downstream capacity as high as 15 Gb/s or 25 Gb/s or even 100+ Gbps. This capability is referred to as Extended Spectrum DOCSIS, sometimes as DOCSIS "dot next." Such a capacity will require spectrum above the typical 1.2 GHz that is supported in current DOCSIS 3.1 equipment, and operators are contemplating using 1.8 GHz or 3 GHz or even as much as 6 GHz or 12 GHz or 25 GHz in spectrum to achieve that capacity[3]. Upstream augmentations to the 684 MHz spectrum permitted by FDX are also being considered to yield higher upstream capacities. Extended Spectrum DOCSIS was originally proposed by ARRIS (now CommScope), and it is being studied by vendors and being considered by MSOs for future bandwidth expansion.

[2] The specifications for R-MACPHY are currently being led by CommScope and under development at CableLabs.
[3] https://www.lightreading.com/cable/docsis/here-comes-docsis-40/d/d-id/743285

Some operators want to Extended Spectrum DOCSIS as an alternative to FDX. Unlike the dynamic switching capability of FDX, which can use much of the spectrum for both upstream or downstream transmissions, they will allocate a portion of the (expanded) spectrum to upstream and another portion to downstream. The upstream spectrum is expanded at split levels at or beyond 204 MHz (example, 300, 396, 492, and 684 MHz), and the top end of the downstream spectrum can be set at various levels, including 1.2 GHz 1.8 GHz, 3.0 GHz, and higher. The utilization of 1.2 GHz systems will typically permit the use of deployed taps, whereas a transition to 1.8 GHz systems or higher will require changes to the existing taps.

Soft-Frequency Division Duplex (Soft-FDD)

In FDD, spectrum is separately allocated to upstream and downstream. Soft-FDD permits operators to configure where the split is and to dynamically change it via software configuration. This is currently another research area that may find applications in both FDX and ESD environments.

Virtualization

Telecom operators have realized the shortcomings and rigidity of their legacy infrastructures and are migrating away from proprietary hardware and software to a software-based environment that runs on common off the shelf (COTS) x86 based servers. This migration is made possible by virtualization, which decouples the functioning of the network from its physical infrastructure, making it more agile and flexible. Virtualization enables the operator to orchestrate resources and networks to deliver the required functionality efficiently and allocate resources elastically.

Virtualization brings significant benefits:

- Reduces time to market for revenue-generating features because operators can make changes continuously and iteratively and are not locked into proprietary hardware nor development lifecycles.
- Increases feature velocity through an open Northbound Interface that allows MSOs and third-party application developers to create and evolve features quickly.
- Develops features for all equipment rather than having to customize for each hardware-based network element by abstracting the software from the hardware, resulting in cost savings and speed to market.
- Enables compute, storage, and network resources to become cloud based and accessed on demand, enabling operators to elastically align resources with market demand, which results in significant efficiencies and cost savings.
- Provides simplified, unified control of all vendors' boxes through the use of open, well-defined Southbound Interfaces (typically implemented by plug-in drivers).
- Facilitates the optimization of network performance using a large feedback control loop with access to all available data sources in the network.
- Opens the door to automation in the service delivery and network operations infrastructures, which results in improved performance and reduces cost.
- Enables the operator to optimize resources across services and applications when modernizing the OSS/BSS and migrating them to data centers. This reduces operating expenses.

Multiservice access node

The multiservice access node, being developed by vendors such as CommScope, enables multiple last-hop technologies to be driven out of a single node, including DOCSIS, PON, Ethernet, WIFI, and wireless. Any last-hop technology is feasible; the challenge is to fit it within the power envelope limits of typical nodes. Through the recent merger of CommScope and ARRIS, the resulting company will be strategically positioned to deliver such a solution in the future.

MODERNIZING THE CABLE PLANT

Operators have a continuum of technologies to consider as they modernize their networks. Some of these technologies, for example, FDX, are not yet ready for prime time, but operators are starting to make architectural decisions based on enabling technologies that are in the early stages of deployment. As they make those decisions, operators should carefully consider their existing network and operating environment, current and future service needs, and assess overall business and operating capabilities. Some of the key options for operators to consider:

Integrated CCAP

This is largely the existing architecture. The integrated CCAP (I-CCAP) is in the headend or hub with the MAC and PHY layers integrated. It connects to an analog node over analog fiber. There is no software in the analog node, and no additional power is needed in the node. The primary benefit of this solution is that it uses established operating methods and procedures and does not require new skillsets nor new networking equipment. The downside is the limitation in terms of current and future capabilities. Essentially, if the operator is increasing capacity in the access network, more equipment will be added in the headends or hubs, and more fiber connectivity will be required. If the added capacity can be achieved with existing real estate and existing analog fiber, then this approach may very well solve the needs of the operator for the foreseeable future, particularly in areas where the need for added capacity is limited. This approach does not easily enable FDX nor future capabilities such as Extended Spectrum DOCSIS.

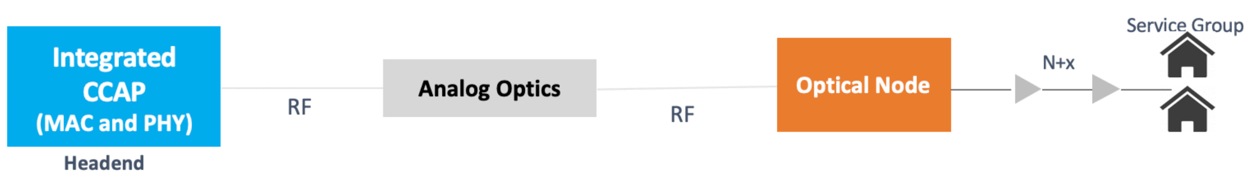

Figure 3. Integrated CCAP

The DAA alternatives

DAA presents a number of alternatives, some short term and others longer term. Selecting the right version of DAA depends on the plant characteristics and business drivers.

R-PHY with hardware-based CCAP core

In this R-PHY configuration, the CCAP chassis remains in the headend and the MAC processing remains in the chassis, and a remote PHY device (RPD) is added to the node. The management and data planes remain in the CCAP; the PHY is moved to the node. Because the RF signal is no longer in the headends or hubs, the analog fiber can be replaced by digital fiber, thus reaping the benefits of digital fiber. Some of the advantages of this configuration include a reduction in rack space in the headend, which results in less power and cooling and less real estate. The R-PHY configuration has the lowest outside plant (OSP) power requirements of DAA solutions. Another benefit of this approach is that the CCAP chassis is largely retained in the headend and hub, which results in less disruption, less training, and fewer changes to operating procedures. R-PHY has significant cost and operating advantages but may introduce latency if the distance between the headend (MAC) and the PHY exceeds 160 km (or if latencies are too large).

Figure 4. Remote PHY with Hardware CCAP Core

R-PHY with virtualized CCAP core

Another R-PHY option is to virtualize the CCAP core, which then will run on COTS servers instead of dedicated hardware. In this case, the hardware chassis that had hosted the CCAP core is replaced by servers, which can reside in the headend or can be consolidated in data centers or other aggregation points in the network. This will fundamentally change the current cable network infrastructure and will move the industry away from customized hardware, thereby aligning it with the broad trends that are overall shaping the telecom industry. A virtualized CCAP core with the right operating environment will enable the cable industry to embrace service velocity, enabled by SDN and NFV principles, because features can now be tested and introduced in an Agile DevOps fashion without the long regression testing cycles and hardware upgrade timeframes. Such a change will require a change in mindset, in training, and in operating procedures, because it requires understanding new software principles to take advantage of the software flexibility. Although vendors are taking great care to replicate the hardware operating environment, the promise of software will only be realized when the operating personnel is re-educated to maximize the potential of the new operating paradigm.

Figure 5. Remote PHY with Virtual CCAP Core

R-MACPHY

In the R-MACPHY configuration, the hardware CCAP element is removed completely from the headend and is replaced by servers that handle the management plane in the form of a MAC manager; the MAC and PHY are moved from the headend to the node where the RMD handles the control and data planes. The server-based management capability can be either in consolidated headends, hubs or in data centers. Co-locating the MAC and PHY in the node results in the lowest latency, which makes it optimal for low-latency applications, such as gaming and VR; this configuration also has the lowest power and rack space in the headend but requires more power in the OSP than R-PHY or I-CCAP. Another benefit of R-MACPHY, just like R-PHY, is that it opens the way to digital fiber, which has benefits in terms of more lambdas, better signal quality, and longer distances; furthermore, because only the MAC manager remains, it can run on COTS, will require less rack space, and opens the way to tap into the benefits of SDN/NFV for service and feature velocity.

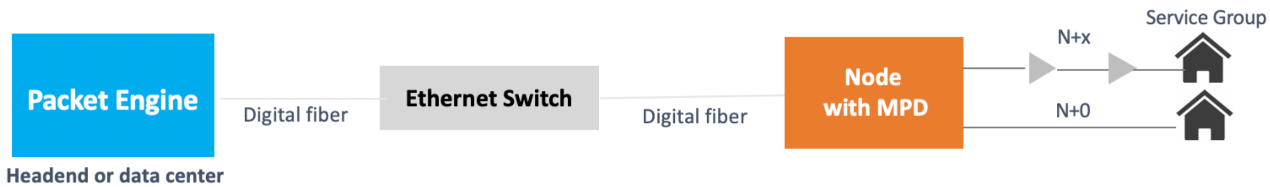

Figure 6. Remote MACPHY

Remote optical line terminal (R-OLT)

Another option for cable operators is to deploy a PON optical line terminal (OLT) in a node-like enclosure at the edge of the network. The OLT houses the MAC and PHY layers, and the MAC management capability remains in the headend. This configuration has similar characteristics to the R-MACPHY approach in terms of lower headend space and power, more OSP power, a path to support service velocity, and is optimal for locations where fiber capacity is needed at the premises.

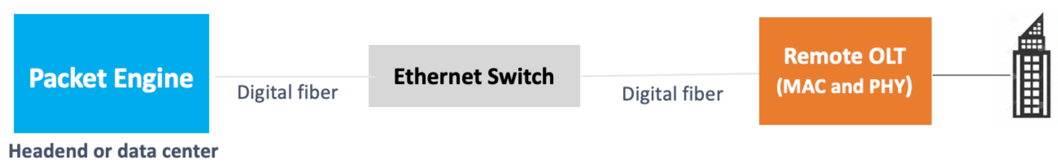

Figure 7. Remote OLT

The network evolution decision process

The options presented highlight the importance of considering strategy, network topology, geographic and demographic realities, legacy infrastructures and other operational and business parameters as operators select the architecture to which they will evolve. The decision process is complex given the dimensions to consider. Figure 8 provides a high-level framework to consider in making the selection. For example, operators that need to provide fiber connectivity to a business or MDU may be best served by deploying a PON architecture in those locations. On the other hand, if fiber connectivity is not a must, a DAA based architecture will satisfy their needs. One of the key criteria to consider in deciding between R-PHY and R-MACPHY is the distance between the MAC and the CPE. For long distances (typically over 160 km), it is best to co-locate the MAC with the PHY in the node (R-MACPHY) to minimize latency for the DOCSIS request/grant cycle. There are a number of other considerations that are not reflected by the decision tree. For example, some operators are loath to place intelligent network elements at the edge of the network where they can be vandalized or be subjected to security breaches; operators with those concerns will likely continue to use I-CCAP solutions.

DAA or OLT are not a must for operators seeking to meet growing market needs. For some operators or in some geographical areas, the capacity of a next-generation I-CAAP with higher module density may be more than sufficient, and the cost of a DAA of FTTH architecture may not be justified based on revenue projections. However, as operators consider staying with an integrated network, they should also consider whether the SNR characteristics of analog optics are adequate and whether they will move to an FDX or ESD solution in the future; if so, then DAA solutions are probably better candidates.

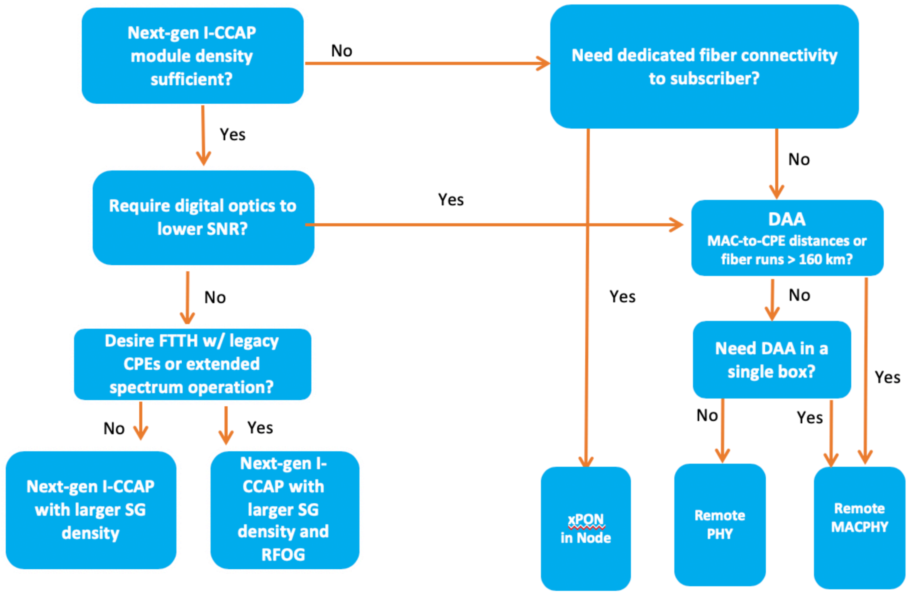

Figure 8. The Network Evolution Decision Tree

The complexity of the decision-making process is compounded by the fact that operators do not have homogeneous footprints; they may need different architectures for different parts of their networks. As their businesses evolve, the architecture that is suitable today may not meet their needs in the future. This creates complexity for the operators and their vendors alike. In the past, cable operators' networks were relatively homogeneous, but in the future, they will be anything but. It is important for operators to partner with a vendor that has a suite of comprehensive solutions that meet their needs today and as they evolve in the future and offer them migration strategies based on solutions proven in the market. Today, some vendors have placed bets on specific technologies (for example, R-PHY or R-MACPHY but not both); these vendors may be unable to meet their customers' future needs if these requirements do not align with the technology pathway they have selected.

The network of the future will likely be distributed and more complex to operate and manage. Therefore, operators need a vendor with a strong support infrastructure with highly sophisticated tools to operate it, which should leverage software and data analytics to drive resiliency, efficiency, and lower costs.

MANAGING THE NETWORK OF THE FUTURE

In the past, the legacy cable network was largely managed through manual processes. For example, installing the analog nodes used to be a primarily manual process and required specialized skills in aligning signals and setting power levels. The new nodes that have an RPD (or RMD) have a software component. In the distributed network, the number of network elements needed to serve a number of subscribers has increased significantly.

To serve 50,000 DOCSIS subscribers	
Integrated CCAP	DAA
One E6000, headend optics and fiber nodes	E6000 with fewer cards + Five 10 Gbps Switches + 200 R-PHY Nodes + Timing servers + Management servers

Table 1. Managing Subscribers in Distributed Network

Operators will require new tools to manage the distributed network. Virtualization opens up significant opportunities for data collection, analytics, and self-healing networks, paving the way for new tools that leverage AI capabilities. At the same time, the subscriber's environment is becoming more complicated, with more devices, WIFI, connected solutions, and other last-hop technologies. Operators need new solutions to manage the new complexity and deliver a good and increasingly digital customer experience. CommScope has developed a suite of software-based capabilities that enable cable operators to optimally operate the networks of the future.

vManager

The ARRIS vManager monitors, manages and orchestrates all headend systems from a virtualized platform. It uses SDN/NFV toolsets, is cloud native, and is based on microservices design principles (each manager is a microservice). Key capabilities provided by vManager:

- Automation: enables distributed network setup and operations.
- Orchestration: goes beyond automation; abstracts the network and the functionality to enable automated configuration operation and management of resources.
- Data analytics: captures data to enable machine learning and ultimately artificial intelligence.

vManager provides optimal value when used in conjunction with the ARRIS vCore, the software-based CCAP core, because the inherent software nature of vCore enables vManager to extract the right parameters and activate the appropriate capabilities.

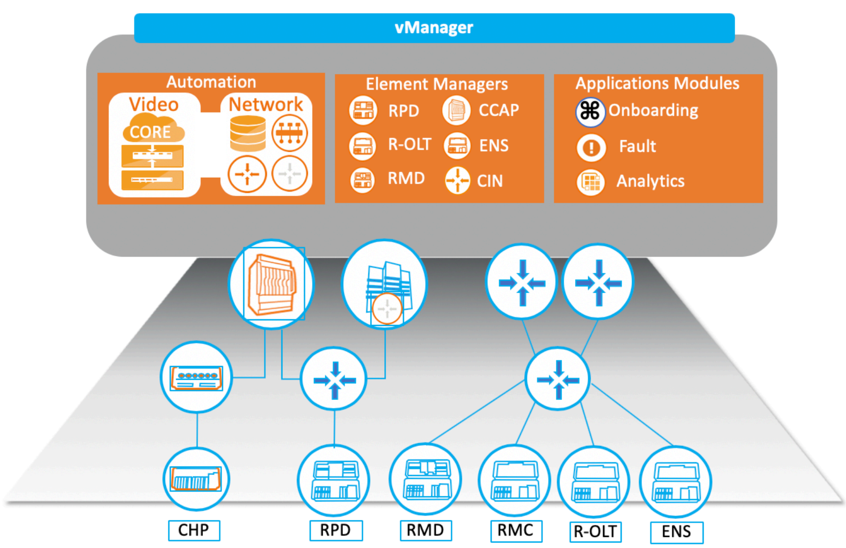

Figure 9. The ARRIS vManager

ServAssure

The ARRIS ServAssure is an access network management solution that leverages data to prevent and resolve performance issues. It collects key performance information about network, field service and subscribers, centralizes it and makes it available to the organizations and applications that need it. The data is used by the artificial intelligence platform for deep analytics, which helps unlock key insights about the DOCSIS® network conditions and service quality. This leads to better network performance, lower operating costs, and an improved customer experience.

ServAssure includes the following modules:

- **ServAssure® Alarm Central** for automated identification and prioritization of existing and potential service impairments.
- **ServAssure® Advanced** for DOCSIS network surveillance and performance management.
- **ServAssure® NXT** is the next-generation ServAssure with support for DOCSIS 3.1 networks and devices.

ECO

The ARRIS ECO system is a service management solution that optimizes the delivery and management of WIFI, the triple-play and the connected home. It simplifies the delivery, management and support of advanced subscriber services, optimizes the management of new services and devices, and addresses the insatiable demand for bandwidth. ECO provides a unified view of subscriber networks and connectivity, enabling the operator to improve the customer's experience and reduce operating costs.

Video Unified Edge

The ARRIS Video Unified Edge (VUE) is a suite of modular software functions that can be deployed in the operator's cloud environment to virtualize the legacy video headend network. VUE replaces traditional video hardware appliances with software functions to simplify the network, automate configurations, and improve uptime. In a DAA environment, the VUE functions as a video core in R-PHY and R-MACPHY architectures that supports both video data plane and video control plane. VUE also unifies the video backbone and advertising in the adaptive bit rate streaming domain.

INTEROPERABILITY

Although the early field implementations of DAA have largely been book-ended by the same vendor (for example, ARRIS at Stofa) because of the complexity of the solution and relative immaturity of the specifications, the industry should aggressively embrace interoperability. Under the auspices of CableLabs, the industry has started this process. For example, ARRIS and Cisco demonstrated interoperability between their respective CCAP cores and RPDs at SCTE in 2017. However, much remains to be done, and it behooves the cable operators to continue driving toward interoperability. To be sure, the distributed nature of the future network will make interoperability more complex but not the least bit less crucial.

CONCLUSION

Cable operators are embarking on a far-reaching transformation of their network infrastructures to meet current and future market demands. They have many alternatives to consider as they evolve their networks, and they have to carefully consider a number of parameters in making this important decision. The complexity of their selection process is compounded by the diversity of their footprints and by the constantly evolving marketplace, which may render their selected architecture inadequate in the long term. Therefore, it is essential for operators to work with a trusted vendor that offers the breadth of solutions they need today and the ability to migrate them to the architecture they will need in the future, all with a comprehensive and deep level of support at every step.

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ARRIS is now part of CommScope via an acquisition. CommScope (NASDAQ: COMM) and the recently acquired ARRIS and Ruckus Networks are redefining tomorrow by shaping the future of wired and wireless communications. Our combined global team of employees, innovators and technologists have empowered customers in all regions of the world to anticipate what's next and push the boundaries of what's possible. Discover more at www.commscope.com.

ACG Research delivers telecom market share/forecast reports, consulting services, business case analysis, product and service message testing. ACG provides you with accurate market share data, strategic and tactical advice, services and products, and timely answers to industry questions so that you can better understand market dynamics and grow your telecom operations more efficiently and profitably.