Distributed Access Architecture: Choices, Challenges and Considerations

A Technical Paper presented by ZCorum

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INTRODUCTION TO DISTRIBUTED ACCESS ARCHITECTURE

Due to the insatiable appetite of subscribers for bandwidth services such as 4k and IP video, coupled with the exploding increase in WiFi, it has become almost mandatory for providers to offer gigabit speeds to homes and businesses. Operators scrambling to meet the demands have typically relied more and more on node splits.

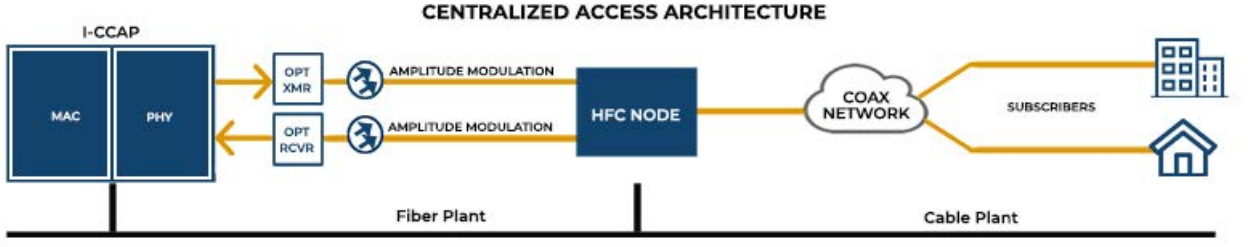
These traditional node splits have been the way operators increase capacity, and while node splits do increase capacity, they also create problems in the headend. As more fiber increases the number of optical nodes in a network, additional physical devices are also required in the headend. These will require more power, more cooling and more space.

Because of these growing strains, operators are by necessity finding ways to make their networks carry more traffic and run more efficiently by evolving their network architecture to meet new bandwidth demands. Shifting some of the traditional headend equipment and functions out to the access network will give operators much higher bandwidth capacity and processing power.

ACCESS ARCHITECTURE

There are two types of Access Architecture: Centralized Access Architecture (CAA) and Distributed Access Architecture (DAA).

Today's hybrid fiber coaxial (HFC) networks with Centralized Access Architecture or (CAA) might be described as active but with no intelligent processing ongoing in the outer plant. This is the most common architecture used by operators today and the vast majority of their nodes are on this type of architecture. The HFC architecture retains all of the functions of the CMTS in the headend, completes all the processing there, where it then goes out through fiber optic cables as analog signals to the node in the plant and out to subscriber's homes. This kind of architecture has served MSOs very well.



But one of the chief challenges of a CAA is the distance limitation of the analog optical transport. Now that operators are transitioning to digital optics for fiber to the node (FTTN), the centralized access architecture (CAA) of the HFC can give way to a Distributed Access Architecture (DAA) wherein the CAA nodes are replaced with digital fiber.

The idea behind DAA is to take some of that processing from the headend and put it out into the plant. With this approach digital transport uses digital optics instead of using analog optics. There are options as to how much of the processing is left in the headend versus moved to the node. These options are what make up DAA. The idea of splitting the functionality and moving some of it out into the plant is the key to saving significant space in the headend and hub.

ADVANTAGES OF A DAA APPROACH

The DAA solutions offer a lifeline for bandwidth pressed providers as both versions of DAA use less power, boost network capacity, free up space in the headend, have a better signal to noise ratio, improve network performance, and provide an overall better customer experience. DAA makes the most of the capabilities of DOCSIS 3.1 technology allowing more data capacity to be packed into the same portion of spectrum. It also supports Full Duplex DOCSIS - enabling multi-gigabit upstream services from existing HFC plants.

With DAA, the forward analog link from the headend is replaced with a digital fiber connection, extending the signals deep into the network before converting them to analog signals at the node. Keeping the data signals in digital format as far out as possible produces less signal interference and improves the quality of the signal to the end subscriber.

Embracing DAA allows for shorter coax distances, which is a necessity for making the network more reliable. With today's extended networks, it's crucial to improve the data path every step of the way. Making this change will offer:

- **Increased network capacity and simpler outside plant maintenance**
- **Better SNR quality, higher modulation rates, higher bit-rates**
- **Reduced headend power, space and cooling requirements**
- **The ability to extend the IP network to the node**

HOW IT WORKS

In general, DAA technologies move certain functions of a network out of the headend and closer to subscribers. The functions of the physical (PHY) and media access control (MAC) layers may be split between the headend and the node devices; or, both the MAC and PHY functions of the CMTS can be placed entirely in the node housing, access cabinet, or even at a multiple dwelling unit (MDU). This extends the delivery network beyond the headend location out to the node or the MDU where the PHY layer or MAC/PHY layer processes would occur, shortening the transport distance.

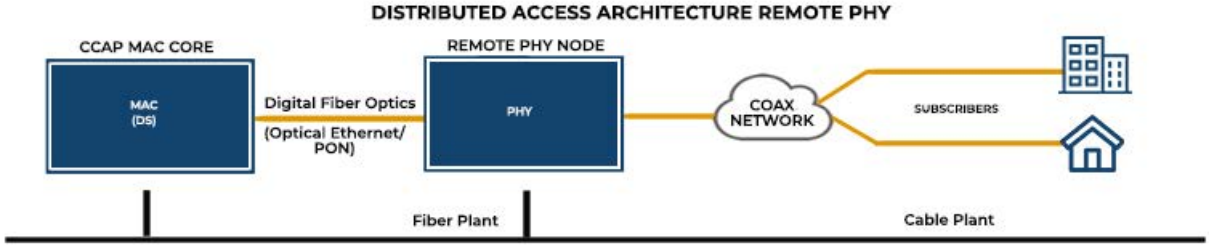
TWO FAVORED OPTIONS OF A DAA: REMOTE PHY AND REMOTE MAC/PHY

Remote PHY and Remote MAC/PHY are the two most common approaches to DAA. The main difference between the two approaches is which functions of the network are moved out of the headend. Remote PHY moves Layer 1, the physical connection layer, out to the node or the MDU. This layer includes the optical fiber, coaxial cable, optical transmitters, optical receivers, RF amplifiers, RF modulators and RF demodulators that move the cable bits across the network.

Remote MAC/PHY moves both layers; Layer 1, the Physical layer (PHY), and Layer 2, the Media Access Control (MAC) layer. The MAC layer provides addressing and channel access components that let network nodes communicate with each other. With the MAC layer and the PHY layer out of the headend, this creates what is in essence a mini CMTS close to the subscriber.

More on Remote PHY

Of the two primary architectures for DAA, Remote PHY is probably the option getting the most notice right now. This is primarily because it is the method being promoted by vendors who make larger CMTS units. In this approach, the PHY layer of the CMTS is split off from the CMTS in the headend and shifted to a new Remote PHY device located within a node in a standalone cabinet, on a strand or inside an MDU. This remote device now handles the conversion of downstream DOCSIS data and video from digital to analog one way, and upstream data and video from analog to digital the other way. After the PHY is relocated, the CMTS core remains in the headend along with the MAC and other upper layers. The big advantage of this approach is utilizing the digital signaling, which provides much better performance in the plant. What's more, leaving the complex MAC layer inside the headend allows for better control and scale.



Benefits of Remote PHY vs Remote MAC/PHY:

- The standards are already specified
- The products are in advanced stages of development

Challenges of Remote PHY:

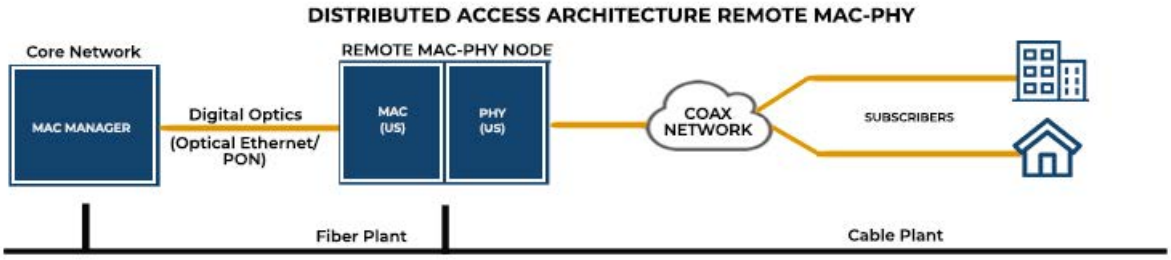
- There can be interoperability issues between the fiber nodes and CCAP cores
- There can be synchronization issues with the communication between the separated MAC and PHY layers
- Training will be needed on how to manage and troubleshoot the communication between the MAC and PHY layers, which traditionally has taken place within the circuitry of the CMTS

More on Remote MAC/PHY

As in the case of Remote PHY, Remote MAC/PHY also focuses on pushing more of the smart functions to the access node, closer to homes at the edge of the HFC network. The Remote MAC/PHY approach shifts all the multi-purpose functionality out of the headend and out to the fiber node. This shifting of both the MAC and PHY layers to the remote access node completely eliminates the need for a headend CMTS as the signal processing now occurs in the access network.

With the CMTS features now built into the remote node, the headend CMTS becomes obsolete. What remains are only routing, switching, and controller functions. This reduces space requirements and lowers energy costs in the headend. In contrast to the Remote PHY only approach, the potential synchronization and communication issues caused by the physical separation of the two layers are avoided since the MAC and PHY layers are both located in the same device.

Remote MAC/PHY also reduces the analog cable plant, simplifying network maintenance and reducing RF issues. The higher signal quality also enables higher QAM modulations which allow for higher bit rates.



Benefits of Remote MAC/PHY vs Remote PHY:

- Additional savings in space, power consumption and a reduction of heat in the headend or hub
- Better RF utilization - ensures the optimization of any future spectrum expansion
- With Remote MAC/PHY you can roll-out DOCSIS 3.1 incrementally by deploying smaller DOCSIS 3.1 Remote MAC/PHY CMTS at the edge in small service areas

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Challenges of Remote MAC/PHY:

- Putting MAC/PHY functions in the node creates additional complexity, such as heat generation and power requirements
- The standardization of MAC-PHY technology is in the course of its development
- Today's products need next-generation silicon solutions in order to lower power consumption

THINGS TO CONSIDER BEFORE CHOOSING A DISTRIBUTED ACCESS ARCHITECTURE

DAA is a concept whose time has come but there won't be a one size fits all solution for an operator's entire installation. Though Remote PHY is being promoted by the major CMTS vendors, a Remote MAC/PHY solution might be preferable in the long run. Each approach has its advantages and disadvantages. Being aware of the issues in advance is important to a successful deployment.

Maintenance

DAA and remote nodes will change the way operators handle equipment maintenance. Devices might be located miles away from the central office, and if the equipment is distributed over several locations operators will need to use remote upgrades as much as possible. There are times when hands-on troubleshooting will be necessary but the hardware has to be sturdy enough to minimize those service trips.

Security

Concerns arise about pushing these complex functions out into the field rather than secured in the controlled environment of the headend. By nature the devices will be deployed in less protected environments and security will be a concern more so than at the central office. In some areas it's not uncommon for equipment to be stolen from the field and sold off. So now the concern is if we put expensive devices out in the field are we going to run into theft issues? Another concern is data security. With some of the higher layers pushed out into the field is it going to be easier to hack into the network and get at data?

All the Different Manufacturers

An additional challenge with a DAA roll out is the current inoperability of all the different devices. And having that issue solved is not expected to happen overnight. For example, operators with a centralized architecture might deploy some Remote PHY devices. If they use Remote PHY from the same vendor as the CCAP they already have in the headend, it's an easy matter of just putting another card in the chassis to support it. Later they may decide to install some Remote MAC/PHY nodes. For now they can expect the new Remote MAC/PHY devices will be provided by a different vendor from his original CCAP and Remote PHY devices and will not be interoperable.

So does this matter? The remote MAC/PHY unit is for all practical purposes a standalone CMTS located on the edge, so it doesn't necessarily need to interop with the CCAP in the headend. But, from a technician's viewpoint and an operational efficiency perspective it might. If the operator doesn't have standardized processes between all of these different architectures, then it could be difficult for technicians to keep up with the different troubleshooting methods and all the subtle differences between them if multiple technologies are deployed.

Other Things to Consider

There are several other factors that should be considered before deciding which route to take:

- **The cost of both deploying and managing each distributed solution** - The costs of the physical equipment needed for the remote nodes and the replacement of any management tools must be calculated. Evaluating the total cost will give operators a clear understanding of their combined capital and operating expenses.
- **The upheaval factor** - Assessing how much change will be required to carry out the transformation is crucial. If the operator isn't ready for these changes even the most productive solution won't help.
- **Future scalability of the network** - Depending on population density and geography of the service area, one method might be more cost effective than the other.

CONCLUSION

It's obvious that moving the cable connection close to the end user and shortening the distance the data travels over RF makes sense. The traditional Centralized Access Architecture is too limiting to accomplish this. So how will cable operators respond?

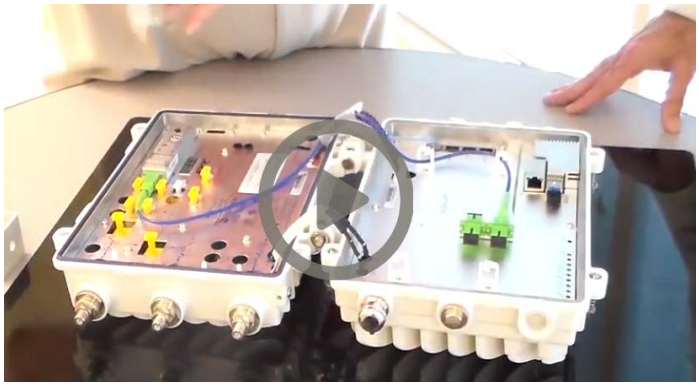
A move to some form of DAA is fast becoming a necessity and can be a major change for cable networks. Deployment and maintenance will require more field work but operators can dip their toe in the DAA water with greenfields or small areas of node splits.

Change is inevitable part of the industry, but a network transformation with Distributed Access Architecture will relieve some of the current demands and open up new opportunities to the providers that deal with it best.

RESOURCES

ABOUT ZCORUM

ZCorum provides a suite of broadband diagnostics and managed services to cable and telephone companies, utilities, and municipalities. As broadband providers face greater complexity and competition, ZCorum continues to help operators increase operational efficiency and reduce costs, while improving the subscriber experience. This is achieved through ZCorum's diagnostics solutions for DOCSIS, DSL and Fiber networks. Managed services include data and VoIP provisioning, residential and commercial VoIP service, branded email and Web hosting, along with 24x7 support for end-users. ZCorum is headquartered in Alpharetta, GA. For more information, please visit us online.



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