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Make the Most of What You've Got: How Cable Modems Can Deliver Economical Cell Site Transport

A Technical Paper prepared for SCTE•ISBE by

Bill Beesley
MSO Business Development Manager
Fujitsu
2801 Telecom Parkway, Richardson, TX 75098
972.479.2098
bill.beesley@fujitsu.com

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1. Introduction

MSOs seeking to increase service delivery speed and reduce the high cost of cell site transport over fiber now have a new option. Low-latency DOCSIS has made the HFC network viable for midhaul and backhaul transport applications. The Telecom Infra Project's vRAN Fronthaul Project Group has developed a means to use cable modems for some cell site transport applications. Using SDN to provide unified management and control of the fiber xHaul; DOCSIS BSOD services; and the RAN, operators can now create the consistent operational views and control needed to fully support this new application for cable modems. This paper will outline the future of wireless transport and discuss how to operationalize cable modems into the existing fiber transport architecture. Topics will include how to implement automated setup and provisioning of network demands, along with a single view of service health, in an overall consistent provider experience whether they use traditional fiber transport or cable modems for xHaul service delivery.

2. A Convergence of Technologies

The Common Public Radio Interface specification or CPRI created a mechanism that allowed the Base Band Unit (BBU) that performs all the signal processing and management to be physically separated from the wireless radio allowing Remote Radio Units (RRUs) to be located several thousand feet away. The original intent of the CPRI specification was to allow distributed RRUs and their antennas to be remotely located on the tower with the baseband processing systems located in buildings a short distance away. Because of this short distance expectation, the CRPI specification has very strict network timing and low latency requirements. The specification also requires transparent layer one connectivity to in-band communication between the BBU and RRU. With an allowed latency of 75 microseconds, wireless operators realized that they could take advantage of economies of scale and lowered operations efforts by centralizing their BBUs in facilities located up to 20 kilometers away from the cell towers. The industry uses the term "fronthaul" to describe the access layer connection between the centralized base band units to the distributed antenna system. Because of fronthaul' s low latency requirements, optical fiber based solutions are the common method for building this access layer. But with millions of disturbed antennas predicted to be deployed to support continued growth of the 5G era, especially in remote and rural areas, the industry is seeking to advance other technologies like cable modems to be able to support fronthaul requirements.

The Telecom Infrastructure Project vRAN Fronthaul Project Group has set out to develop solutions that would allow the connection between the baseband unit and the remote radio unit to have much lower latency requirements than currently allowed by the CPRI specification. The first round of technology labs testing access technologies such as PON, G.Fast and cable modems was completed in 2019. CableLabs® served as the community lab that provided proof of concept testing for the use of cable modems and they were able to successfully demonstrate support for fronthaul services over an HFC network in their lab environment. While non-ideal fronthaul is still in the proof of concept stages as of the time of this paper, the results are promising and could be standardized and supported by the radio vendor products in the next few years. This would do much to accelerate the deployment of 5G services and give cable operators another viable choice for access network transport of fronthaul. (see https://telecominfraproject.com/vran/)

In parallel to this activity, CableLabs® has developed mechanisms to significantly improve the latency in HFC networks. Because of the communications handshakes between the cable modem and the CMTS and the nature of the way DOCSIS schedules upstream timeslots, latency in the HFC network has generally been way too high to ever consider it for use in the split RAN architectures described above. The industry needed to be able to support applications like gaming and split RAN xHaul which have very low latency demands. CableLabs® accomplished this by introducing low latency DOCSIS for gaming and low latency xHaul for wireless transport. Many papers go into the details of how both of these work but a simplified description is that by modifying the scheduling mechanism to be preemptive and allow for parallelism it becomes possible to get the latency of the HFC network down into the one to three millisecond range. While this does not currently support fronthaul, in combination with non-ideal fronthaul at some point in the near future it will be entirely possible to support all xHaul architectures via the HFC network.

But as we move into the "can we" question of using HFC for fronthaul, we also need to consider the "should we". No network tool is universal and there are several operational considerations for using coax versus fiber to support the deployment of fronthaul based radio units

3. Choices, Choices

The first consideration is the utilization of the asset itself. Wireless deployments are not "bursty" like residential or other commercial data users. Today, a radio unit will use the maximum amount of bandwidth with only one radio connected to it. In addition, the preemptive nature of low latency xhaul means that some amount of upstream bandwidth will need to be allocated in case the radio needs to communicate with the base band unit. When planning for future cable modem based fronthaul deployments, the question will need to be asked if the HFC bandwidth could be used for other revenue generating services. In addition, HFC network reliability is significantly lower since all but one MSO does not use a ring architecture. Depending on the sizing of the wireless service group, thoughtful consideration will need to be given as to whether it may make economic and operational sense to deploy fiber even where coax may be readily available. Of course, where fiber assets are unavailable, or too expensive to extend, coax will still be a great option for fronthaul. Operations staff will just need to measure the options.

An old telecom service adage goes something like, "it is easy to deploy the first service. It is deploying the next ten thousand that is hard." As the paradigm for fronthaul services moves into the HFC world, operations staff will need to be retooled and retrained to support a new class of customer. Wireless carriers have much higher service level expectations than existing residential and commercial HFC based customers. This, along with the introduction of new technologies such as remote radio units will increase expectations placed on frontline operations staff. One example of this change was experienced a bit over ten years ago when the first cable modem based, strand mount wireless hotspots were introduced into the market. A major cable operator in the US decided to deploy this new technology to support wireless data based services in public spaces and event areas. These devices were mounted on the existing HFC strand and obtained both their access and power from the coax to deliver a public hot spot service. What the cable operator quickly learned was that the outside plant technicians didn't have a working knowledge of cable modems and wireless access points and that the wireless data engineers did not have experience working with HFC hardline, plant power and even if they did, they didn't have bucket trucks. It because quickly clear that these groups were going to have to develop new tools, training and working methods in order to successfully ensure the delivery of the new service.

When considering adding coax as a service delivery mechanism for fronthaul, operations teams need to plan on how they will deploy the new service in a consistent and repeatable manner. How will service

adds, moves and changes be managed quickly and efficiently? Who will monitor and manage service health and how will they accomplish this? There will be new tools, new methods and of course, new training necessary. Frontline operations leadership needs to carefully document and prepare their teams for the changes that will come.

Another consideration often overlooked is that there are a large number of wireless carriers currently supported by the MSO fiber infrastructure. In the US, the cable companies own the majority of fiber infrastructure delivering services to wireless carriers. Pat Esser, Chief Executive Officer for Cox Communications shared during a Fox Business interview from the floor of the Consumer Electronics Show in 2019 that they provide the fiber to 82% of the cell towers that are located in their footprint. Due to the fiber rich nature of the HFC architecture, it is likely other MSOs are enjoying similar service numbers within their footprint. As the cable industry evolves toward delivering some wireless xHaul via cable modems there will need to be a mechanism to provide unified and consistent management and support for the customer where their services are running on both fiber and coax networks.

4. An evolution

The industry will need to evolve towards support for a unified topology paradigm that allows the end-to-end management both fiber and coax networks along with the wireless radio network. New technologies like software defined networking controllers will be required to allow for collaboration across these network domains in order to not only support functionality, such as 5G network slicing, but also to allow operations teams to be effective. Future networks will require operations teams to shift from managing network equipment to managing customer services. Services will need to be automatically created at both the fiber access and DOCSIS network based on service demands from the wireless access layer and then effectively chained together to provide an end-to-end service. To avoid the need to add additional operations resources as new, more complex services continue to be added to the network, it will become the software management layer that will be the critical linchpin in the operators network. Software interfaces will need to become more open. Systems will need to allow for more intelligence and automation. Emerging technologies such as AI/ML will need to be introduced into the management of the end-to-end network. The alternative is operational overload.

5. Conclusion

The cable industry is at another turning point in service delivery. Wireless deployments will continue to grow exponentially to meet growing demand for more bandwidth and lower latency. As the deployment of fiber deep assets to support HFC allowed them to secure the access transport for the majority of the cell towers deployed in the past, the MSO community is well positioned to support the next round of wireless growth. But they will need to prepare more than their network technologies to support this next wave of new services. They must also invest in and prepare their operations systems and teams. By doing so, cable networks will continue to be the dominant method for delivering access transport for wireless deployments

Abbreviations

AI/ML	artificial intelligence/machine learning
BSOD	business services over DOCSIS
BBU	base band unit
CMTS	Cable modem termination system

CPRI	common public radio interface
DOCSIS	data over cable service interface specification
HFC	hybrid fiber-coax
G.fast	ITU-T G fast access to subscriber terminals
MSO	Multiple system operator
PON	Passive optical network
RAN	radio access network
RRU	Remote radio unit
SDN	Software defined networking
vRAN	virtualized radio access network
xHaul	fronthaul, mid-haul, backhaul