Bringing Service Visibility Into The Light With CPRI As A Service

A Technical Paper prepared for SCTE•ISBE by

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1. Introduction

The Common Public Radio Interface (CPRI), which is commonly used to connect cell sites and base stations, imposes ultra-low latency and transparent communications requirements that effectively force operators to provide dark fiber to carriers who purchase their services. But using dark fiber for a single service to an end customer is not only a wasteful use of a high-value asset, it is operationally inefficient. Dark fiber gives no visibility into the services the customer is running, and consequently the operator has no proactive way to monitor and manage the health of these services. Often, operators are alerted to outages when the customer calls to report them, which is, at best, a weak mechanism for support visibility. This paper will outline how new technologies—such as low latency Ethernet and hybrid active/passive networking—enable operators to create CPRI-as-a-Service offering that overcomes this key disadvantage, improves overall management and maintenance of their xHaul networks, and lets them reclaim valuable unused fiber assets.

2. Are we stuck in the dark?

One of the little known secrets in the industry is that Cable Company owned fiber services the vast majority of cell towers in the United States. 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.[1] Within the United States the fortunate convergence of a regulatory environment that created a robust private cell tower ecosystem and that resulted in the MSO community investing a rich fiber deep network infrastructure resulted in the majority of wireless carriers opting to lease xHaul services from the cable companies rather than investing in this infrastructure themselves. In the early days of xHaul, SONET was often used to provide traditional TDM based transport of bandwith from the cell tower back to the wirless service provider's telecommunications facilities. Over time as higher performance and lower cost Ethernet transport became available, this became the preferred transport mechanism commonly served via MPLS services from the cable company. In parallel to this transport evolution the wireless telecommunications equipment located at the towers also evolved an important technology.   The Common Public Radio Interface specification or CPRI, created a mechanism which allowed the Baseband 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. This low latency, transparent communication link between the radios and base stations is commonly referred to as "fronthaul" and unlike legacy backhaul networks could not be supported via MPLS or Ethernet service offerings from the MSO forcing them to use dark-fiber to support the transport needs of the wireless carriers.

But dark fiber is an extremely valuable asset.   In the United States the average cost to build out fiber infrastructure is around $100,000 per mile, assuming a blended aerial and underground mix. Not only is that a difficult return on investment model, especially considering that the perceived service value of the carrier purchasing dark fiber service is that it is in the range of lit Ethernet services, repaying out a fiber build in the tens of thousands of dollars from a single cell town is a real challenge.   Now it should be pointed out here that when fiber is built, we do not just pull a pair of fibers as the general practice is to pull a sheath of fibers with hundreds of fibers.   While these extra fibers can be used to facilitate other

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network needs such as multiservice distributed access or other commercial customer buildouts, the needs of the other services may not be optimally placed in relation to the cell tower. The question should also be asked, "even if I can pay the cost of the build and/or make some profit off providing dark fiber service….is that the best fiscal use of this high value asset?" A single fiber strand can provide services to hundreds, and sometime thousands of residential and commercial subscribers. Dark fiber service delivered to the tower orphans that asset to a single customer.

While the economics of providing dark fiber as a service are arguable, there will always be a need for dark fiber and there will always be companies willing to offer it, what is not debatable is that dark fiber is difficult to monitor for service health.

Wireless carriers are notorious for their high expectations of service health and reliability. Since they are service providers themselves, they have an accountability to what can be hundreds of their customers who may be impacted by outages. Since the MSO will have no visibility into the network equipment connected to the dark fiber, they will also have not be able to monitor service health. This often means that the first notification of a customer affecting outage the MSO will likely receive is when the customer calls to tell them they think they have an issue with their fiber. Since the MSO has no visibility into the services running on the fiber they are left blind to the root cause of service degradation. Is the cause an impairment caused by damage to the fiber, an issue at the CPRI or Ethernet layer, or some other issue? Without visibility into the service layer the opportunity for finger pointing between customer and provider in the fog of war that comes with service degradation effecting multiple downstream customers becomes a common event that can negatively impact the relationship between MSO and carrier.

So, is the option only to offer dark fiber with its high cost and low service value because the needs of the CPRI protocols cannot be support by traditional Ethernet or MPLS? The good news is that technology has evolved and the options are no longer just a binary dark fiber or nothing to satisfy the requirements of wireless carriers.

3. New technologies to change the game

One set of technologies that is a game-changer in the ability to introduce concepts known as low latency Ethernet and/or Time Sensitive Networking. Time Sensitive Networking is a series of standards built on the 802.1 working group standards that allow Ethernet to support very low latency and jitter as well as introducing strict network time synchronization required to so support CPRI fonthaul applications as a service.[2] The technology advancements introduced by TSN have allowed for the introduction of CPRI as a service. Much like traditional SONET, ATM and Ethernet services, CPRI services allow the MSO to deliver the service requirements of ultra-low latency and strict network time synchronization while also allowing them to manage, monitor and maintain the quality of the service to ensure a consistent and high customer experience level. Still, having the technical capabilities to deliver a CPRI service may not be sufficient by itself to wean carriers off their dark fiber addiction. Since there are fiber over builders often willing to construct in fiber, many MSOs have been reluctant to push their customers to a CPRI service offering out of concern that another fiber provider will overbuild their footprint, a very real risk. So, we need to discuss how to increase the customer perceived value of the service and discuss new service capabilities that will improve the customer experience.

But first, we need to touch on one other networking technology that is also viable for carrying carrier distributed antenna network, passive DWDM. It is quite common for larger wireless carriers who also have some of their own fiber to use passive DWDM with tunable optics to carry distributed antenna traffic in their networks. There are a good variety of 10G and 25G single-and dual-fiber options that can plug directly into the remote radio units to carry the traffic back to the baseband unit for processing.

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Much like DWDM is used for DAA and business services traffic in the MSO network, this is an excellent low cost option for metro networks. However, just as with dark fiber, passive DWDM lacks service layer visibility and monitoring. Unless the MSO has visibility into the edge equipment carried on the passive network, they will have no idea that there is service degradation until the customer calls them and even then, it will be just as difficult as with dark fiber to quickly troubleshoot and isolate the root cause.

As stated previously, wireless carriers justifiably, have a high expectation for service availability and quality. What is needed to elevate the level of these technologies to a true service offering is a way to make the network more intelligent, more automated and easier to manage and maintain, and more transparent to both the MSO and to the wireless carrier.

It is becoming increasingly more common for modern network transport and access equipment to be equipped with standardized APIs and YANG models to allow them to be part of a Software Defined Networking or SDN ecosystem. SDN allows operators to evolve the paradigm of network management from provisioning to programming. By imagining a network as a programmable set of components that can obey defined rule sets and consistently report information such as network topology and system and service health, we can take advantage of SDN technologies to create new service capabilities.

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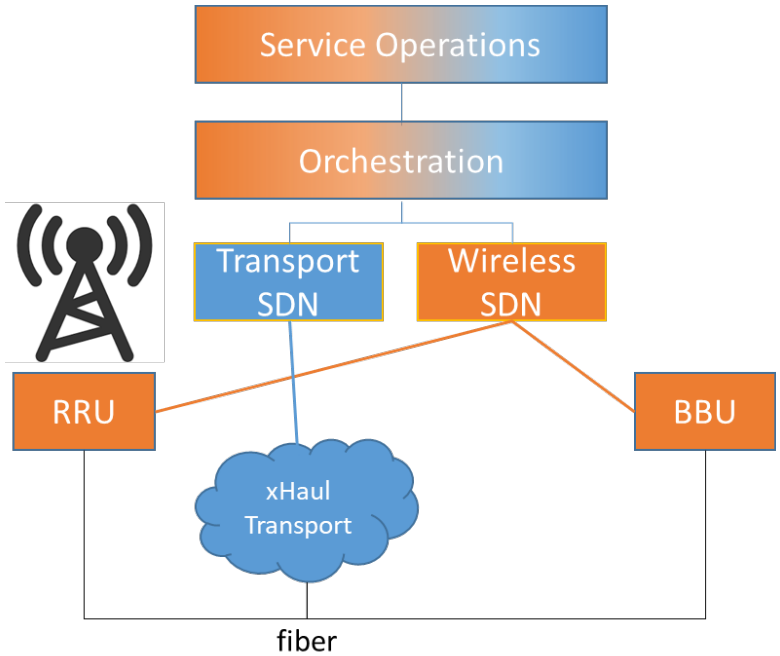

Figure 1 - Unified Software Control

In figure 1 we see a block diagram example of how we can use software control over the end to end network to provide a unified operations view for both the MSO and the wireless operator. Taking advantage of open APIs we have a transport SDN controller that is within the MSO network and a wireless SDN controller in the wireless operator's network. Both the wireless and transport networks are controlled by an orchestration system and service operations that both operator and customer have delegated views into but with walled garden control. Both operator and customer can "see" the status of the other network and their orchestration systems can respond to and honor network demands from the controllers as well as provide unified topology and management views of the end-to-end network and its health.

This mixed management methodology will operate and behave based on service rules agreed to between operator and customer. Operations engineers familiar with traditional network management systems and more importantly the lack of multi-vendor and multi-layer management capabilities will undoubtedly be skeptical of the image in figure 1. This has traditionally been true as both network equipment and management systems have been closed, monolithic ecosystems lacking a high degree of flexibility and extensibility. But, modern network automation software is capable of introducing this new functionality into existing operations and control systems. Today we can take advantage of open APIs and microapps to introduce functionality into operations systems incrementally without the need to tear out the existing infrastructure. This method is also capable of connecting multiple vendor systems because it can integrate either with existing management platform northbound APIs or integrate directly with the network infrastructure itself via document YANG model. Both of these mean that no longer must a new, monolithic system be stood up next to existing infrastructure. The MSO can add the new functionality a service at a time using microapplications and microservices.

One example of where using software automation to modernize networks is improving the functionality of passive DWDM networks. As previously stated, traditional passive DWDM networks allowed for very

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limited visibility into the topology and health of the underlying transport infrastructure because there was no direct way to query this equipment. This meant, as an example, If an operator wanted to provide a service level topology view of their network their technicians would be required to manually provision wavelength services as they were added, moved, or deleted. Since manual efforts like this are both labor intensive and fraught with potential for error, the result was that not many if any operators have a live topology view of services running on their passive optical networks for monitoring and troubleshooting purposes. In addition to a lack of service visibility as passive networks require the client pluggable to be correctly tuned to the wavelength supported by the port into which they are plugged, they increase the operational effort to provision network additions or changes. They also increase the potential for error as the technician can select the wrong port or pluggable.

Modern smart pluggables overcome this issue as they are tunable across the full optical spectrum and are able to determine which wavelength they should auto-tune to in order to establish service. These pluggables are also capable of some service monitoring to determine the health of the optical link. By using software intelligence to monitor this, a micro-application can be introduced into the network management system to determine which wavelength the pluggable is tuned, correlate this with the known passive topology, and then draw a visual representation of the service path through the passive network. This can then be later used for system alarming, showing the network operations team that not only that the pluggable is in alarm, but the expected path through the network. This provides additional service context that can be useful in quickly isolating and resolving service faults. Additionally, the operator can provide the smart pluggables to customers who are connecting in their remote radios or other devices to the passive network. Since the pluggable will auto-provision and tune to the appropriate wavelength, the wireless operator can self-install their equipment once fiber has been terminated at the appropriate demarcation point. As the pluggable can be monitored by the MSO, they now have service visibility for the optical layer without having to have access to the customer's edge equipment. This topology is known as Hybrid Active/Passive and can greatly improve the customer experience while improving MSO installation and operations efforts.

4. Conclusion

In addition to allowing for multi-layer, multi-vendor operations, these modern systems often have well documented APIs it becomes practicable to implement intersystem communications and control between operator and customer. Since the implementation can be done on a per-function application via a micro-app or micro-service, this integration work can be done within the context of a specific customer agreement and the cost of implementation can be tied to the revenue generated by that agreement. Open systems and open architectures in the transport and wireless networks and their control systems mean we can now extend automation and visibility of the network to allow for lower operations effort and provide a better customer experience.

Advances in time sensitive and hybrid active/passive networks now allow the capability to carry wireless operators xHaul traffic in an efficient and reliable manner negating the use of dark fiber as the only method to support the needs of wireless operators. These technologies are deliver a better customer experience by enhancing the MSO's visibility into the service health, which is not feasible with dark fiber. These technology advances are likely enough in their own right for MSOs to justify offering CPRI as a service in lieu of dark fiber.

But the industry should not stop there when considering their xHaul service offerings. With modern software intelligence, further improvements can be added to the service that increase collaboration and trust between the MSO as a transport operator and the wireless carrier. Ultimately these will lead to an increase in customer satisfaction and increase the product "stickiness".

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Abbreviations

DWDM	dense wave division multiplexing
DAA	distributed access architecture
MSO	multiple system operator
HFC	hybrid fiber-coax
HD	high definition
Hz	hertz
ISBE	International Society of Broadband Experts
SCTE	Society of Cable Telecommunications Engineers

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