Remote PHY Deployment Options

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Abstract

All Internet Service Providers are challenged by the ever increasing demand of our customers for higher speeds and more consumable bandwidth. In order to meet that need we must come up with new ways to optimize our spend to keep capex and opex under control, while we also try to find new opportunities to increase our revenue with exciting new services.

This paper describes how to use a new technology known as Remote PHY Device (RPD) to develop a well thought out strategy to increase capacity by using node splits, fiber deep deployments, DOCSIS 3.1, IP video and mid-split. Our use of the term RPD is not limited to a PHY-only device, it would also be applicable to a remote MAC-PHY or remote CCAP device, we use it generically to mean placing the PHY into the outside plant and do not differentiate where the L2 and L3 functions would exist.

1.0 INTRODUCTION

"The report of my death was an exaggeration." – Mark Twain, 2 June 1887

"Mine too…" – DOCSIS, 9 March 2016

The demise of DOCSIS has been predicted since it first appeared in the mid 1990's. Yet, to this day it continues to be deployed and to drive new technologies into its ecosystem enabling a bright future for high-speed internet over cable.

It has been said that cable, in particular hybrid fiber coax based networks can not compete with other technologies. As an industry we have proven that false by intelligent use of node splits, adding new DOCSIS carriers, channel bonding, higher order modulations, new parity coding, OFDM, and on…

However, even with the innovations brought forth by a number of creative individuals and companies, we recognize that we need to continue developing new technologies and uses of existing ones to provide the long useful life that many of us believe that DOCSIS has left.

One specific technology we believe will have a significant impact on the future potential of DOCSIS is distributed access architectures (DAA). DAA places pieces of the CCAP architecture into the HFC plant closer to the end users. In our example we use the generic term RPD to mean remote PHY, remote MAC-PHY and remote CCAP. The end result is the same in that we get fiber and PHY layer technologies closer to the customer.

2.0 BACKGROUND

To start, we need some common terminology which will be used to describe the service provider (SP) network. For the purpose of this discussion, we will break the SP network into five layers.

1. Backbone
2. Metro
3. Edge
4. Outside Plant
5. CustomerPremise

For the purpose of this document we will be focusing on the edge, outside plant and customer premise. We can draw the network that we historically have deployed as depicted in Figure 1.

In Figure 1 we show the traditional placement of fiber nodes and a migration path from node plus 5 actives, to node plus 1 active, to a node plus no active layout (passive coax).

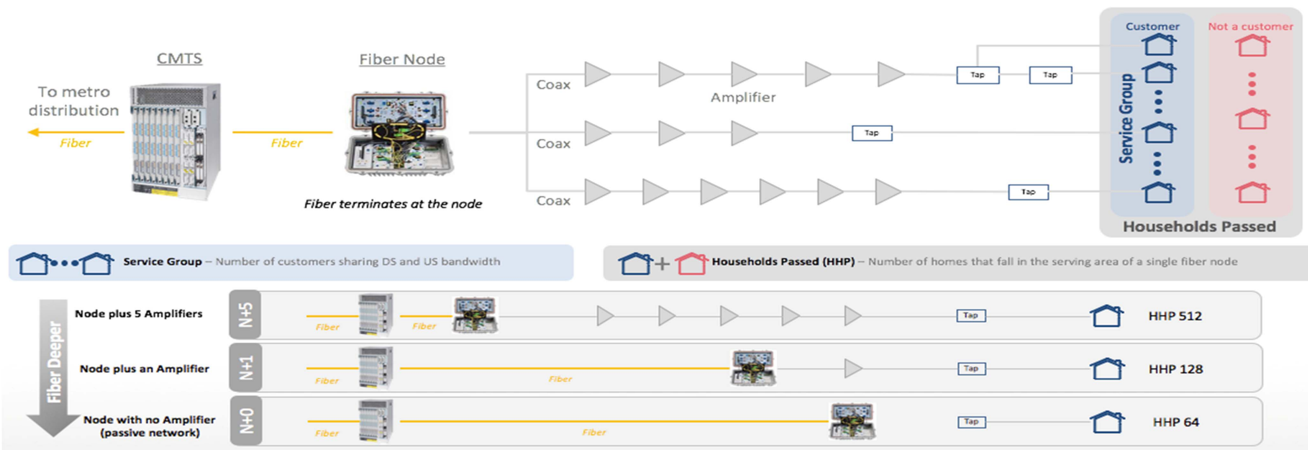

Figure 1 - CCAP Access Network

If we show the same drawing, but this time replacing the CMTS with a CCAP and the fiber node with a remote PHY device (RPD), the drawing would look as shown in Figure 2.

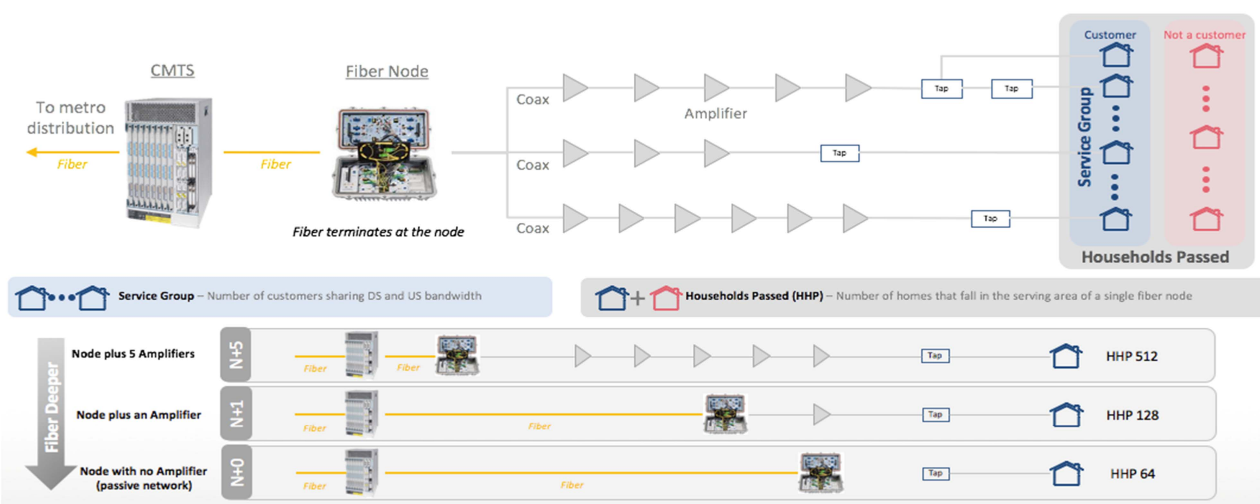

Figure 2 - Remote PHY Access Network

The biggest change in this scenario is that the CCAP core no longer contains a PHY chip (or at least does not use, even if placed in its integrated PHY chips). The MAC uses the Downstream External PHY Interface (DEPI) and Upstream External PHY Interface (UEPI), to communication with the RPD over an ethernet link.

3.0 REMOTE PHY ARCHITECTURE

The Remote PHY architecture is described in the "DCA-MHAv2" CableLabs specification (ref [1]). DCA stands for "Distributed CCAP Architecture" and MHAv2 is "Modular Head-end Architecture Version 2".

MHAv1 was the separation of downstream only, with keeping the upstream on the CMTS. This became known as the "Modular CMTS" architecture and facilitated use of edge QAM devices for the physical layer.

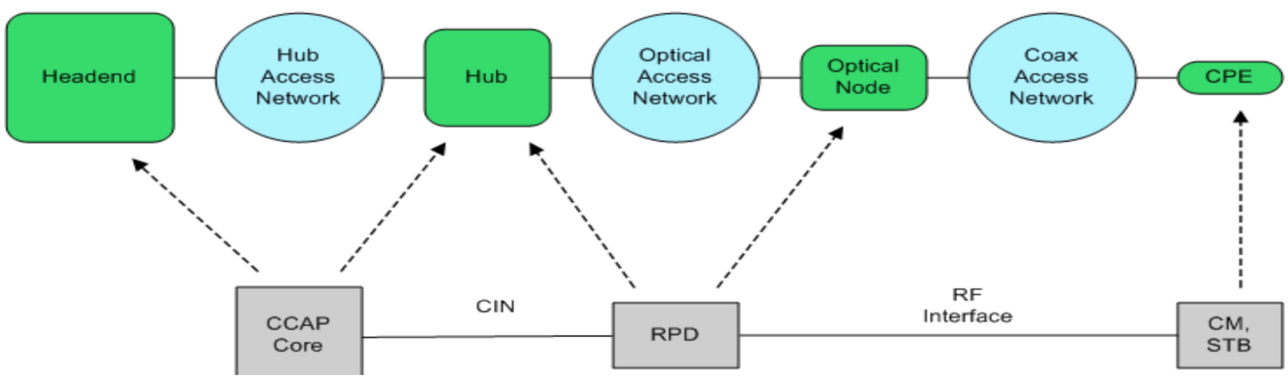

Figure 3 - Remote PHY Architecture

At a basic level, the Remote PHY Device solves a simple problem: the number of coax connectors that can be attached to a linecard in a CCAP box is limited. As a result the physical connectivity of a CCAP might be lower then the actual traffic processing capacity.

For example, consider a case where there is room to attach only 64 coax connectors, each carrying 5 Gbps of data with a forwarding engine capable of forwarding 500 Gbps. In that case the total amount of traffic that can be connected is 5x64 = 320 Gbps, which means all the forwarding capacity of the box is not utilized. With a Remote PHY this basic problem is resolved because we can now use regular Ethernet switches to aggregate a large number of Remote PHY devices.

However, the ability of the RPD to serve as a "port extender" for CCAP is only the beginning. With the remote core we can both:

1. Place the RPD at a great distance from the core, only limited by the contraints of the timing method used to synchronize the downstream and upstream. This can work over 100 miles or more.
2. Allow a flexible allocation of RPD to core. In essence, we have a pool of Remote PHY Devices and a pool of core resources that can be matched in many configurations. This allows for the creation of "virtual serving groups" that share a common MAC
3. Attached to different cores, e.g. CMTS core, broadcast EQAM core, VOD/SDV core and OOB .

In the following section we will see how these capabilities allow for a flexible and scalable deployment model.

4.0 REMOTE PHY DEPLOYMENT OPTIONS

The following section outlines the remote PHY deployment models, but it also presents them as a transition strategy. The CCAP architecture can be migrated from the current "hub in a box" monolithic model of a fully converged access solution into a virtual cloud application in several steps, all enabled by the Remote PHY technology:

1. The first phase is to deploy the RPD in a "port extender" mode. There are only two components required. The physical core and a set of Remote PHY Devices.

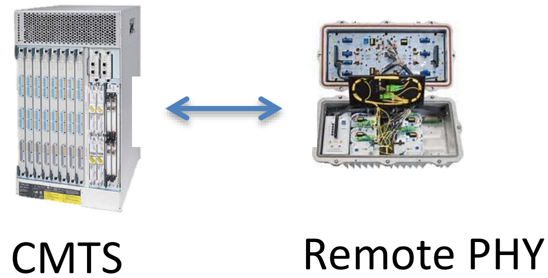

Figure 4 - Physical CMTS With RPD As A Port Extender

2. The second phase would be to attach the RPD to a remote CCAP core, still in a port extender mode, but over a greater distance and over multiple network hops.

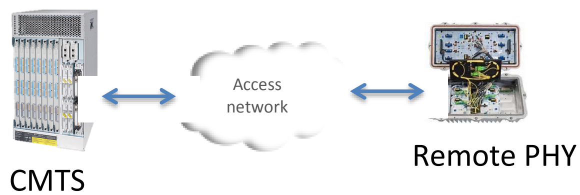

Figure 5 - Physical CMTS with RPD as a port extender across a network

3. For the next phase an operator can use a 3rd tool : a orchestrator and a set of controllers that will mix and match remote phy and cores as needed without fixing a particular core to a particular remote phy. The role of the orchestrator is to implement a "workflow" of instructions needed to select the RPD to core association as well as create and validate the connection between them. Under the orchestrator there can be a couple of controllers, each specializing in a particular domain, e.g. access, network etc.

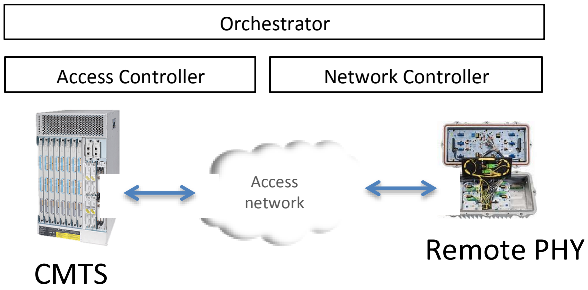

Figure 6 - Orchestrated Virtual CMTS

4. The controller can assign some of the remote phy devices,, to a virtual instance. Initially the virtual instances can be standalone – in that mode they are a CMTS implemented over a generic server platform, but not yet part of a "real cloud"

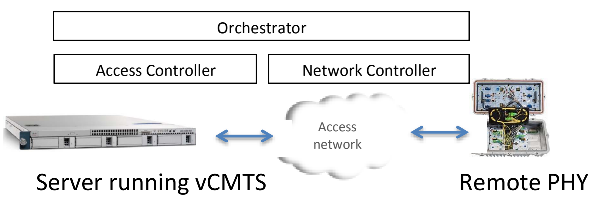

Figure 7 - vCMTS In An Appliance Mode

5. A fully orchestrated virtualized solution where virtual instances are created on demand and linked to other Network Function Virtualization (NFV) service chains. Note that one controller that's added in this configuration is the "data center controller" as depicted in the figure below:

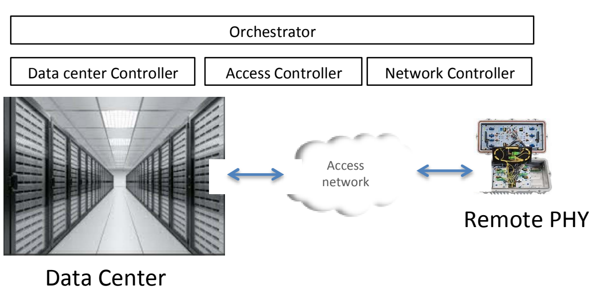

Figure 8 - Remote PHY Data Center deployment

An operator can create systems that have a bit of any of the architectures mentioned about as "transition phases", for example, its possible to have the active instances of a vCMTS deployed as an appliance and only the redundancy instances deployed in a data center. The flexibility is because the remote PHY has to point a tunnel is a core, without caring about how far the core is or whether it's physical or virtual.

5.0 SERVICE GROUP SIZING

Because the remote PHY processes information at layer 1 only its completly imprevious to the service group size or the number of subscribers in the service group. It is simply a "Coax-in-fiber-out" device. Therefor when planning for serving group sizing the only planning criteria are those related to cost, bandwidth and RF span.

6.0 THE UNCONVERGED CCAP

A lot of the "Convergence" in CCAP (Converged Cable Access Platform) was achieved by frequency stacking on the physical port. A single port that can support a full spectrum motivated a system design that generated the full spectrum, including MPEG transport and data, in a single box. However, in the remote PHY architecture the frequency stacking occurs at the remote PHY itself, and that enables a "de-convergence" of the MAC where separate appliances or virtual machines drive different parts of the spectrum, each being able to scale, test and upgrade independently.

7.0 CONCLUSION

There is no simple answer of how to best deploy distributed access architecture. As service providers we desire to deploy new technologies in ways that are least impactful to our existing customer base. This many times requires that we slow down our deployments and plan our strategy carefully to minimize outages.

Remote PHY Devices, are particularly well suited for smaller service group sizes, that in the future will reduce our downtime as many plant related conditions today require truck rolls and hands-on tuning of lasers and amplifiers. In the RPD world, lasers are digital which will lead to lower maintenance costs over analog lasers and simplified configuration. The pairing of RPD with Proactive Network Maintenance means that output power levels may be fine-tuned remotely, which means a better user experience from those customers closer to the RPD to those at the end of the coaxial network.

Finally, with RPD comes the ability to position ourselves for a lower cost passive coaxial plant, which leads us to the possibility of a future version of DOCSIS that may even be full duplex.

These benefits are not limited to a pure remote PHY, but are equally a consideration for other distributed access architectures including remote MAC-PHY and remote PON. In all scenarios the one undeniable fact is we end up with fiber closer to the customer, which is something that prepares us for future needs.