Dipping Your Toe in Virtual CCAP?

Journey & Early Field Trials Lessons Learnt

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1. Introduction

The DOCSIS 4.0® specifications are the emerging Next-Generation Access technology that allows MSOs (Multiple System Operators) to provide symmetrical multi-gig broadband service to our customers. It extends the runway of our current HFC (Hybrid Fiber Coax) plant, addresses our customers' increasing bandwidth requirements, and compete with telco competitors' fiber offerings. However, to introduce DOCSIS 4.0, MSO's must first modernize their CCAP (Converged Cable Access Platform) networks with Virtual CCAP and DAA (Distributed Access Architecture) technologies, which are essential cornerstones to DOCSIS 4.0.

Rogers Communications has started evaluating Virtual CCAP in our lab since 2019, and has conducted multiple production trials since 2020. This paper will share our journey of evaluating and introducing vCCAP, the architecture decisions we made, pros, cons and challenges with each of these design options, as well as various lessons learnt along the journey.

Note that this paper is vendor agnostic, the assessment is based on the industry technology and will not discuss pros and cons of vendor specific vCCAP platforms. Also, this paper will not try to repeat existing Virtual CCAP or DAA standards or guidelines that are readily available from CableLabs and other industry sources. Instead, this paper will focus on Rogers's journey in introducing this new technology, and share architectural decisions and our lessons learnt through lab and Production trials.

2. Why Virtual CCAP

Many MSOs have taken the journey over the past 30 years evolving their broadband network from DOCSIS 1.0 to 2.0 then 3.0 and 3.1. Today in 2024, many MSOs face fierce competition from telcos offering multi-gig symmetrical services over their FTTH (Fiber to the home) network. DOCSIS 4.0 is a next-generation DOCSIS technology that allows MSOs to offer multi-gig symmetrical service over their HFC plant, and many MSOs may naturally select DOCSIS 4.0 as the next hop for Wireline Access network evolution to compete with the telco's. However, note that in 2024 there are other technology options that should be considered, and it is best for MSOs to consider all of them based on their circumstances and requirements before they decide on the next step in their technology roadmap :

1. **DOCSIS 3.1 Enhanced**

   Introduced as an interim step between DOCSIS3.1 and DOCSIS 4.0, DOCSIS3.1Enhanced (D3.1E) allow MSOs to keep their current-generation CMTS network (Integrated CCAP or RemotePHY-CCAP) and significantly increase the bandwidth via CMTS software upgrade and DOCSIS4.0-capable cable modem in customer homes.

   DOCSIS3.1E increases the number of downstream OFDM channels from 2 to 4 or 5 (dependent on CMTS platform and RF spectrum availability. This is easily an equivalent of 30-100% bandwidth gain in downstream bandwidth. The other advantage of DOCSIS3.1E is it can be supported via current generation CMTS platforms (i-CMTS) over traditional analog HFC nodes. This allows MSOs to defer the high upgrade cost for DAA plant uplift, and enable D3.1E over their current generation i-CMTS or RPHY-CMTS via software update (if supported by their CMTS vendor). Operators have to replace customer premise equipment (CPE) with D4.0-capable cable modem, and also ensure there is adequate RF spectrum to accommodate additional OFDM/A channels, which often will drive RF spectrum shuffle and/or digital video spectrum consolidation / reclamation. This will still be significantly cheaper than DAA uplift in most cases.

Alternatively, MSOs may take another step towards DOCSIS4.0 evolution by introducing Virtual CCAP coupled with RPHY-shelves to replace the current generation CMTS appliances. This allows MSOs to replace the old legacy CMTS equipment which may lack roadmap support or faces end-of-support hardware issues. Virtual CCAP with RPHY shelves will achieve significant power and space savings in the hub sites. The vCMTS is also future-proof to support DOCSIS 4.0, and the Cable Operator can strategically select analog nodes to upgrade to DAA only when and where DOCSIS4.0 is required for additional bandwidth; while the rest of the network will still support DOCIS3.1E and provide adequate bandwidth to subscribers over the next 5- 10 years. Note that the RPHY-shelves are a regrettable spend as they will not support DOCSIS4.0, however they are also relatively inexpensive and defer the costly DAA field uplift till later.

2. FTTH PON

Taking the leap directly from DOCSIS3.1 to FTTH PON will have a significant upfront capital cost, but it supports symmetrical multi-gig bandwidth immediately. XGSPON provides symmetrical 10Gbps of bandwidth (8.6Gbps payload), and 25G-PON and 50G-PON are going to be available in the immediate future. By uplifting the HFC plant with fiber to the home, MSOs will not require any future major uplift of the access plant, as future PON technologies can be supported via OLT module and ONT upgrade over the FTTH plant. A purely passive Access network plant may also reduce future maintenance/upgrade work, lower operating and maintenance cost. FTTH PON deployment does require significant capital cost investment, majority in the fiber access network uplift cost. It also represents a significant shift in Operation model and requires time and resources in Operationalization of the PON Access technology.

2.1. The Drivers for DOCSIS 4.0

Naturally as MSOs consider their options in the next step of Access Network modernization, we should objectively compare DOCSIS 4.0 to DOCSIS3.1E and FTTH PON. When Rogers compared various next-gen broadband Access network technologies, we consider DOCSIS4.0 and its underlying Virtual CCAP / DAA technology still offer many advantages:

A. Cost

In our cost analysis we find that despite the per home cost of FTTH has come down in the past decade, it still costs significantly more to upgrade most homes with FTTH compared to DAA in the Canadian market. In our study we find the headend cost (PON BNG vs. vCMTS per port cost) is comparable, but the field cost which includes actives (RemotePHY node and amplifiers up to 1.8GHz in the case of HFC, OLT in the case of PON), fiber, and passives (taps in the case of HFC, LCP in the case of PON) is still 5x to 7x higher for PON mainly due to extension of fiber network all the way to customer homes.

B. Legacy Video service

Virtual CCAP is compatible with QAM-based legacy video services. Operators can choose to deploy Virtual CCAP with Remote PHY shelves while RF-combining the legacy video service in the headend (similar to iCMTS architecture), or DAA RPD's are compatible with an Auxiliary Video Core that can preserve the Legacy TV service.

In the long run MSOs will likely need to fully migrate legacy TV to IPTV and reclaim the spectrum and maximize the broadband Internet bandwidth. Nevertheless Legacy TV service sunset is a long and tedious process, and there are financial impacts migrating customers to IPTV as well. Virtual CCAP offers the compatibility for MSOs to pace the sunset of Legacy TV, whereas FTTH PON does not support Legacy TV service at all.

C. Learning Curve for Maintenance and Support

Cable companies Operations and Maintenance teams are familiar with DOCSIS, RF level and HFC plant, and maintaining a Virtual CCAP / DAA network is familiar to Cable workforces. While there are training that is required upgrading from an analog optical node to an RPD, or from a 750MHz amplifier to a 1.8GHz amplifier, the access network remains an HFC plant and from a training and education perspective the Virtual CCAP / DAA is a step in evolution instead of PON which is a brand new network. The training and impact to Network Operations will be significantly lower with Virtual CCAP / DAA network.

It should also be noted that in our study, while the DOCSIS 4.0 has cost advantage with a lower net present value (NPV) and a lower upfront cost to provide multi-gig bandwidth to our customers, in the long term roadmap to symmetrical 10Gbps, the total capital cost is comparable. By reducing the upfront cost via the DOCSIS 4.0 path, it does also have the disadvantage where there are multiple network upgrades over the journey to symmetrical 10Gbps: Service Operator must upgrade the network multiple times first migrating from appliance based CMTS to Virtual CCAP, then upgrading from analog node to RPD, then upgrading the amplifiers and passives. And each network upgrade introduces a learning curve to Operations and Maintenance, not to mention significant network changes causing network downtime and Operations impact. Comparatively, upgrading network to PON has a significantly higher upfront cost but it is also a one-time network upgrade. Once the Service Operator has end-to-end fiber to customer homes, future upgrade to 25Gbps or 50Gbps PON is relatively simple with little customer or Operations impact.

Also, PON also has a bandwidth advantage for mid-sized and enterprise business customers being able to offer symmetrical 10Gbps service today and upgrade to 25+Gbps easily via OLT card and CPE upgrade in 1-2 years time. PON also shows strength in Wireless services compatibility as well as other areas such as network latency. These are all factors Cable Operator should carefully consider and evaluate before deciding on a network modernization strategy and roadmap for each strategic market.

3. Virtual CCAP : Architectural Considerations and Options

Virtual CCAP is a new technology that virtualizes the network function of CCAP into software functions that runs on COTS (Common-Off-the-shelf) servers. This dramatically changes the way vendors deliver their CMTS solution, as the containerized COTS environment offers both advantages and disadvantages over appliance-based environment. This chapter will walkthrough some of the options available to Rogers because of the switch to Virtual CCAP, the pros and cons and the analysis behind the architectural decisions that we made, as well as some technical concerns or weak points of Virtual CCAP platforms that need special architectural accommodations.

3.1. Common Cloud Optimization

One of the many advantages of Network Function Virtualization is to be able to have multiple network functions share the same Cloud infrastructure, allowing operator to optimize hardware resource efficiency and standardize on virtualized network function management using the same orchestrator and same management tools.

While this is true for less resource intense network functions (like DHCP, DNS, PCRF etc.), integrating the Virtual CCAP to a Common Cloud environment presents a different challenge which requires further considerations for the Operators, and potentially also drives further technology development by the vendors:

a) Virtual CCAP application is extremely CPU processing power and memory resource intensive, and is not very efficient to share hardware resource with other network applications
b) Virtual CCAP application requires multiple 100Gbps I/O interfaces, which is expensive and very uncommon for other network functions that often require 1Gbps or 10Gbps interfaces only. The difference in I/O interface speed makes it difficult to share hardware infrastructure
c) For server redundancy, Virtual CCAP applications often require servers to be configured in clusters of multiple physical servers, and this makes sharing hardware with other network functions more complicated
d) As of 2024, most Virtual CCAP platforms are containerized applications that run on bare metal servers, and do not support any type of hypervisor. This makes it very challenging to integrate vCMTS into any type of common cloud environment. Some vendors do support hypervisor support for orchestration and management in their future roadmap, but requires commitment and influence from Operators to realize this roadmap feature.

For these aforementioned reasons, at the present time Rogers considers standardized container on baremetal servers is the right architecture for Virtual CCAP application, and will closely monitor the development of the technology and the industry direction to determine if integration into common cloud makes sense in the future.

3.2. Timing & Synchronization

DOCSIS standard requires that for Remote PHY architecture, tight PTP (Precision timing protocol) signal synchronization must be maintained between the CMTS core and the RPD (Remote PHY Device). In the case this timing signal is lost (due to loss of GPS antenna, for example), holdover mechanism is built into both CMTS core and RPD devices to maintain the timing synchronization for a certain period of time while the Cable Operator can trouble-shoot and recover synchronization. Beyond this holdover limit, which in the Appliance-based CMTS world is typically 1-2 hours for the CMTS core, then the RPDs will begin to lose connection from the CMTS core and customers will experience service outage. Maintaining the resiliency of the timing network is a critical architectural element in the Remote-PHY architecture for network availability and survivability.

In migrating CMTS from appliance-based baremetal to COTS-based virtualized application, one of the limitations is vendors can no longer use Cesium timing components to maintain the same 1-2 hours of synchronization holdover in the case of PTP (Precision Timing Protocol) signal loss. This is because CMTS vendors can only leverage capabilities of what is offered on COTS hardware, and COTS server that are generally used in data centers do not require the same kind of synchronization resiliency. As a result Virtual CCAP core typically has a synchronization holdover limit of 30 minutes instead of 1-2 hours on appliance-based baremetal CMTS's.

This is a very important architectural consideration because timing synchronization loss can not only be caused by physical defects (such as cable cut to GPS antenna), but more often they can be caused by logical disconnection (such as failure of TOR router, firewall changes or configuration changes blocking PTP signal flow etc.). Worse, Synchronization Network defects are often hard to diagnose, as their impacts are gradual and over multiple different network elements. If synchronization is lost for the vCMTS core and cannot be recovered within the ~ 30 minutes holdover time, this will cause service outage to all subscribers fed from the CMTS core, which can be a significant number of over 100K or 200K homes.

In attempting to protect the Virtual CCAP network against such failures, Rogers have taken the following architectural measures for Synchronization network :

a) **Provide redundant PTP feeds to every vCMTS core**. Further, we design the Synchronization network so that each vCMTS core will be fed by 1 local feed (GPS antenna at the same primary hub location) and 1 remote feed (GPS antenna from another primary hub location transported over the Transport network). This protects the Sync network against local GPS antenna or Grand Master failures.

   To further reduce the chance of failure, in the design shown in Figure 1 below, the design of the Synchronization network routes the primary and backup feeds over different networks : the Primary connection is a direct Layer 2 (Ethernet) signal from the grandmaster to the TOR switch, where the backup route traverses through the Management network from a remote site. This further reduce the chance of losing PTP synchronization signal due to TOR switch misconfiguration or failure. To separate the primary and backup PTP feed on different networks does increase the planning complexity, and Operators may decide if they need this extra layer of protection, or if they would simplify the Synchronization network design by feeding the backup route via the IP Core / Transport network to the same TOR switches to the vCCAP cluster.

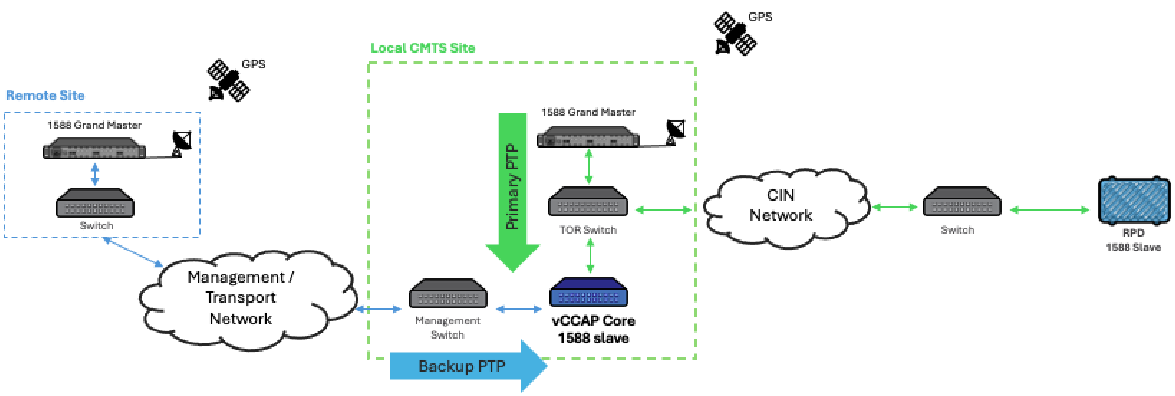

Figure 1 – Redundant Synchronization (PTP) Network Design

b) **Simplify and reduce hops from the PTP feeds**. Remove unnecessary routing and network elements from the synchronization feeds to the vCMTS core, feed Layer 2 Ethernet feeds into TOR (Top of Rack) router if possible. This greatly reduces the chance of loss of PTP signal due to logical network changes.
c) **Extend the Holdover period**. Work with vCMTS vendor to extend the sync network holdover time as much as possible. Rogers has successfully worked with a vCMTS vendor to extend the Core holdover period from 30 minutes to 1 hour, doubling the time for Operations team to trouble-shoot and recover the Sync network before an outage occurs.

Due to the large customer base fed by the vCMTS core and the high sensitivity of Remote-PHY architecture to timing & sync signal loss, Timing & Synchronization resiliency is an area that Operator cannot afford to overlook when designing the vCMTS architecture.

3.3. Geo Redundancy and Disaster Recovery

In the traditional DOCSIS Remote PHY Architecture, customer cable modems are homed to a single CMTS over a Remote PHY node and CIN network. This means Cable Modems have a 1:1 relationship with a CMTS, where their registration as well as subscriber profile definition exists on only a single CMTS. Since DOCSIS standards does not support re-homing of single cable modem (CM) to backup CMTS in different geographic locations, in the case of a site disaster where the entire primary hub site is lost (due to fire or fiber cut to all fiber routes into the building, for example) all the subscribers fed from the primary hub will be lost for a long duration, potentially days of service outage.

This site loss maybe triggered by a catastrophic event such as site fire, or fiber cut of both primary and backup fiber feeds into the site. In those scenarios the incident can easily affect a ‘blast radius’ of over 100K or 200K subscribers for duration of days. Some MSOs deploy “Disaster Recovery Trailers” with critical equipment such as CMTS, power generator etc. to speed up the service recovery time in such situations. However DR Trailer will still require a lot of fiber splicing, as well as manual or semi-automated restoration of network element configuration (including CMTS, and IP Core, CIN network etc.) and potentially takes 6+ hours before service can be restored.

With Virtual CMTS, even though the DOCSIS limitation of single-homing cable modem still exists, the fact CMTS is virtualized allows MSOs to quickly instantiate and re-create the same CMTS instance at a backup location if backup server infrastructure exists. This gives the Operator the option to create a semi-automated Disaster Recovery process over geo diverse sites within the restrictions of the DOCSIS standards. The restoration process will follow these high level steps :

1) Service Operator must prepare and maintain backup server infrastructure at geo redundant sites. The DR vCMTS capacity can follow a pre-defined 1:n backup scheme, where each backup site can cover multiple (n) primary sites, the backup DR capacity must be sufficient for the worst case (maximum) capacity of all primary sites it covers, and the DR capacity is powered in ‘cold standby’ mode during normal operation.
2) In planning the CIN network, the vCMTS architecture must also ensure each RPD is dual-homed to primary and backup sites.
3) In the case of a site disaster, the Operator can instantiate the vCMTS instance and re-create the lost vCMTS Core node at the backup location by restoring its last backup configuration. This process can be automated by automation script to shorten the restoration time. This process can be completed in minutes.
4) In parallel, the RPDs previously connected to the lost site will be re-directed to the backup site via the CIN network.
5) Once both Step 3 and 4 are complete, the RPDs will automatically re-register on the restored vCMTS, and after the CMs will also re-register. All broadband services will be restored within 1-2 hours instead of days without a DR trailer, or 6+ hours with a DR trailer

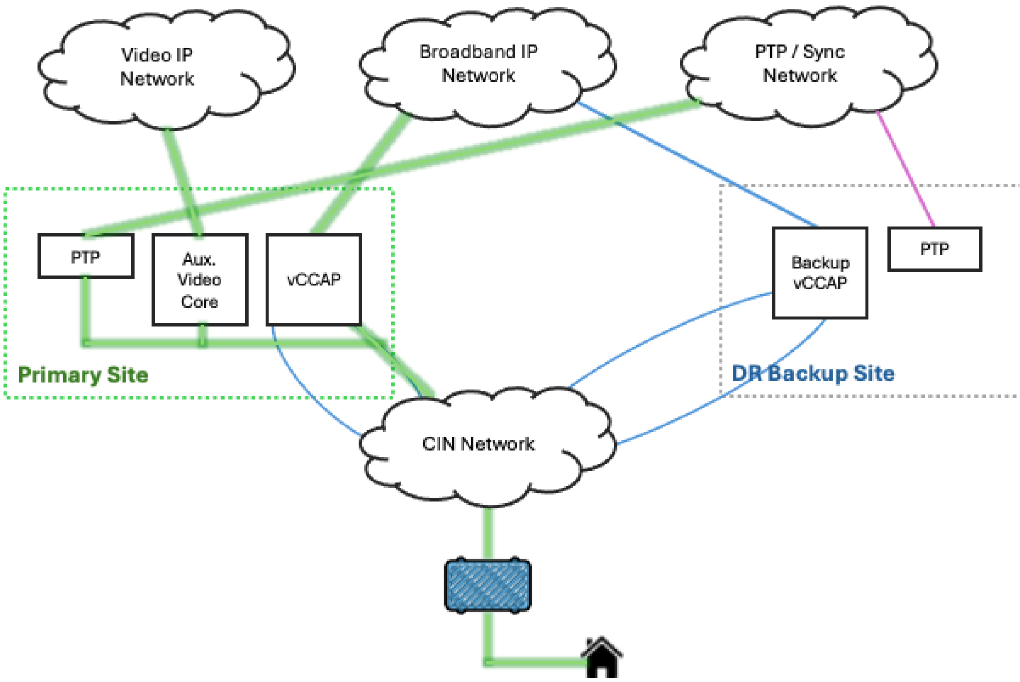

Figure 2 – Geo-Redundant vCCAP Design

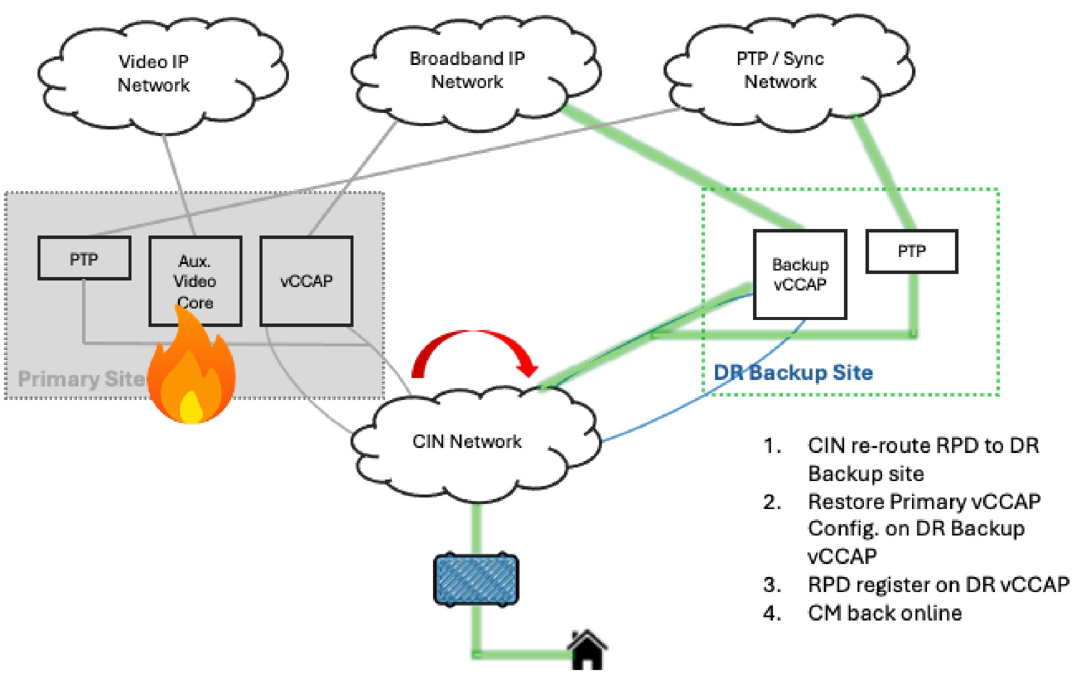

Figure 3 – Geo-Redundant vCCAP Failover

Note that while this will restore broadband (Internet) service for all CMs fed through RPDs, this does not restore direct-fed RPDs that do not connect via the CIN network. Those RPDs will need to be restored via a DR trailer, or when the lost site is recovered. This restoration also may not restore Legacy (QAM based) Video services, Voice services or business services, as those services do not terminate on the CMTS and need further architectural effort to design their automated disaster recovery procedure. Nevertheless this design should recover the majority of the subscribers and services fed from a primary hub lost to disaster, and should be considered by MSOs for big sites.

3.4. Centralized vs. Distributed vCMTS

With current generation appliance based CMTS, MSOs generally deploys CMTS in distributed sites close to customer homes (typically within 45 to 60km, although there are exceptions). This is because of DOCSIS3.1 distance limitation (DOCSIS3.1 specifies the CMTS to CM distance to 80 km maximum, but also states typical distance is shorter than that for performance reasons), and there are limitations by other services such as Legacy 2-way Digital video services.

The introduction of DAA (Distributed Access Architecture) relaxes the distance limitation between CM and CMTS, but it still did not allow MSOs to fully consider a Centralized CMTS architecture because of appliance based CMTS port density, power and space requirements. A Centralized CMTS architecture would significantly increase the HP (Homes Passed) fed from the primary hubs, and typical this presents a big challenge for hub sites to accommodate the scaling of space and power growth that comes with using appliance based CMTS equipment due to their lower port density and higher space and power requirements.

However, with the combination of Virtualized CMTS and DAA technology, the headend power and space requirement per HP is reduced, and it allows MSOs to consider a centralized architecture when planning the deployment plan for the next-generation vCMTS platform.

With appliance-based DOCSIS3.1 i-CMTS, MSOs have a distance limit of ~ 80 km maximum from the CMTS in the primary hub to customer home. The downside of this architecture is MSOs require more CMTS sites across their geographic footprint, and incur the Operating and Maintenance expenses that come with these sites, not to mention the power and space requirement for appliance-based CMTS is much higher. Further, due to the regular maintenance work that appliance-based CMTS requires, very often (but not all the times) CMTS sites are also technicians-located sites. This also impacts how the MSOs need to distribute the workforce among geographic regions and sites.

With Virtual CMTS and DAA, because vCMTS offers much higher port density compared to appliance based CMTS; and that DAA relaxes the distance limitation, Cable Operator can now extend the distance from vCMTS to RPD to well over 120km. This allows the Cable Operator to change their vCMTS network design, centralizing from numerous CMTS sites in a large metropolitan region to a handful of sites. In Rogers's analysis, we were able to consolidate from ~ 40 sites in a large metropolitan area to ~ 20 CMTS sites using vCMTS. The vCMTS sites will feed distributed CIN sites (or secondary hub sites) which will now house only the CIN switches and optical transport components with significantly lower power and space requirements. Most of these secondary sites are shelters. Since the CIN and optical transport platforms require less frequent maintenance work, these Secondary hub sites often do not need on-site technicians. In Rogers's network design analysis, we recognize there is a significant power (~30%) and space (~80%) saving in upgrading from appliance based CMTS to vCMTS, and also shifting towards a more centralized CMTS network design.

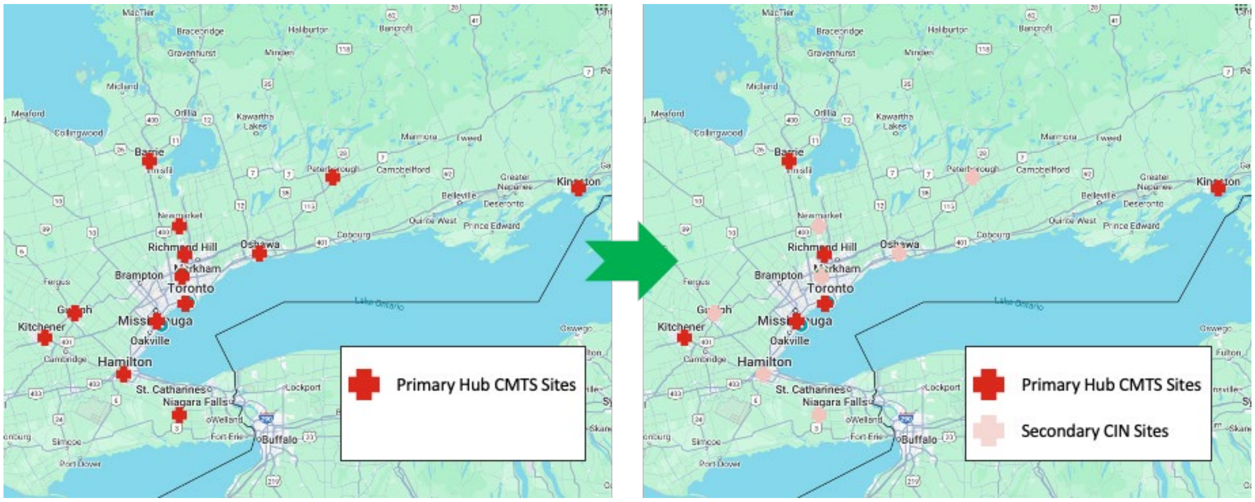

Figure 4 – Example of Primary Hub Site Consolidation via vCCAP

However, in shifting towards a centralized design, MSOs need to consider the followings:

1) **Blast Radius** – In consolidating from, as an example, 40-50 CMTS sites to 10-15 sites, it greatly increases the number of customers served from each primary hub. In a disaster scenario, the loss of site may have impacted 40-50K customers in a distributed CMTS network, compared to now 200K or even 300K customers in a complete loss of vCMTS site. MSOs need to consider due diligence plans such as Geo-redundancy as mentioned above, and also consider the acceptable level of risk in realizing the financial savings from site consolidation.

2) **Legacy QAM Video** – While next-gen vCMTS and DAA relaxes the distance limitation for optical node, Legacy QAM video services may still have distance limitation beyond which 2-way services like Video-On-Demand (VOD) and Interactive Channel Guide (ICG) will no longer work. When planning CMTS network centralization, MSOs must take into consideration the limitation and requirements of Legacy Video services.

3) **CIN Network Route Diversity** – For network survivability in case of fiber cuts or equipment failure, Cable Operator must consider route diversity from the secondary sites (or distributed sites) back to the vCMTS sites via CIN network. This is especially important because in a consolidated architecture the homes passed served by each distributed sites is higher than in a distributed direct-fed DAA architecture.

   MSOs must also be mindful of the CIN span distance for the primary and backup fiber routes, because if there is a significant distance difference between the 2 routes the latency configuration will be different, and RPDs may fail to register on the CMTS once switched to the backup fiber route. This may be addressed by configuring the CMTS to the longer route latency, though this will impact the customer latency experience even when the shorter primary route is used. Alternatively Cable Operator can use Dynamic Latency Management (DLM) feature to automatically adjust latency setting when the CIN route is changed if this is supported by the CMTS platform.

4. Lessons Learnt from Virtual CMTS Trials

Rogers initially begun lab testing of Virtual CMTS systems in lab in 2020 and conducted the first field trial in 2021. Since 2021 Rogers has conducted multiple field trials with different vCMTS platforms and software versions over both Remote PHY Node (RPD) and Remote PHY Shelf (RPS). This section will share some of the Operational lessons learnt from these vCMTS trials.

4.1. Savings in Power and Space

One of the main advantages in Virtual CMTS compared to Appliance based CMTS is savings in power and space. In our design analysis, we have selected a current primary CMTS site with iCMTS and calculated just by migrating from “big iron” CMTS to Virtual CMTS with the same capacity, we would realize a ~ 75% space saving and ~ 14% power saving from switching. Note that space and power saving is site specific, and a higher saving can be achieved from larger sites. This saving is important because with the increasing capacity demand from both CAGR traffic growth and subscribers growth, many CMTS hub sites cannot scale with the growth in CMTS capacity and would require major facility expansion to support the power and space requirements. The migration to Virtual CMTS essentially erases the requirement for facility expansion.

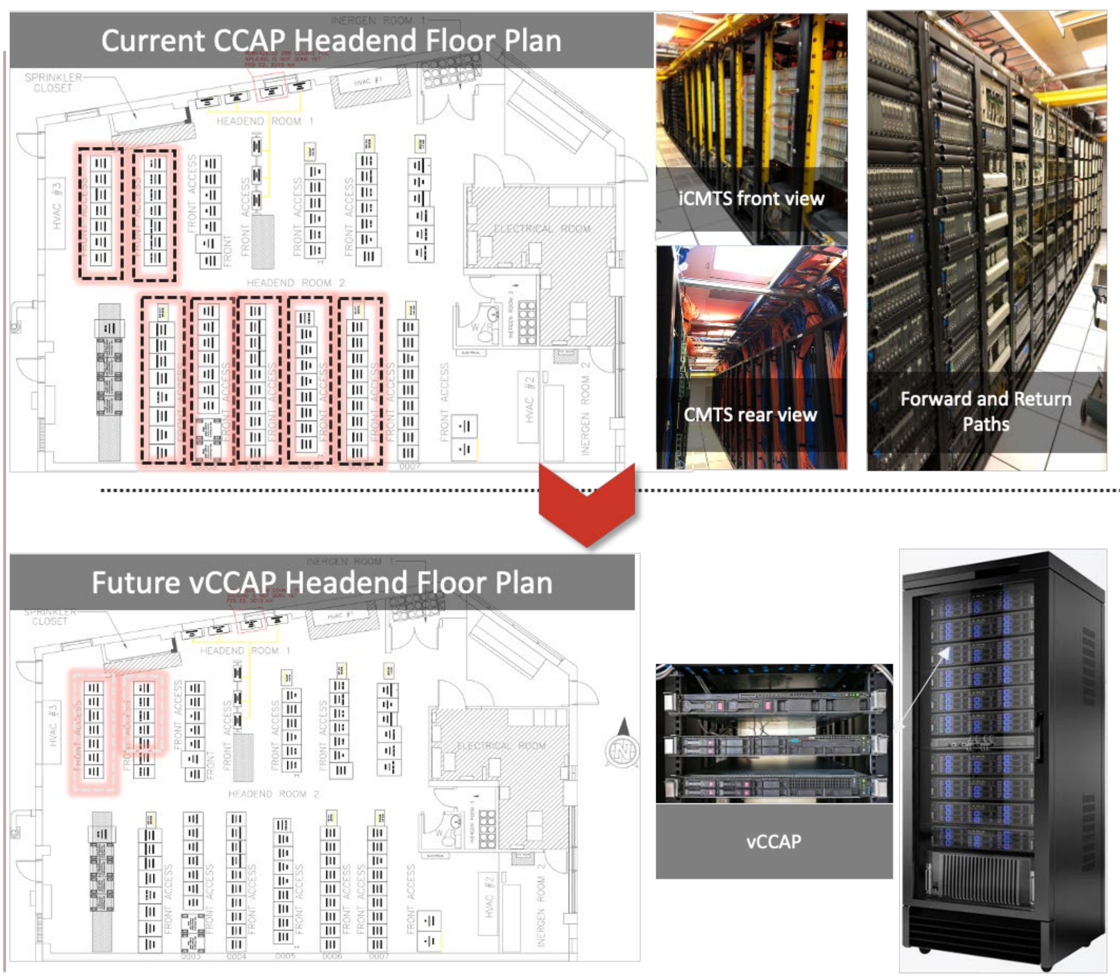

Figure 5 – Example of Power and Space Saving Analysis

4.2. Shift in Support and Maintenance Model

In the current appliance-based CMTS model, service providers purchase the entire CMTS solution from the vendor including the hardware, software, license, network management, etc., and the operation and support model is very straight forward. If there is any defect or deficiency with the CMTS, the service provider would obtain support from the CMTS vendor regardless if it is hardware or software related.

Shift to the world of Virtualized CMTS, and this is not necessarily so straight forward anymore. Because the vCMTS software is now running on containers over COTS hardware, the MSO may find themselves in a situation where the CMTS vendor is only responsible for support of the vCMTS software, and a different COTS hardware vendor for the support of the server hardware, and yet another software vendor for the support of the Operating System. Defect diagnostic becomes a lot more complicated, and bug fix or system recovery can easily turn into a finger-pointing exercise and difficult to hold a single party responsible.

To accommodate this shift, MSOs will need to evolve their workforce and their Operations team on training and developing expertise in Cloud hardware and Operating System so they are well equipped for operations and maintenance in a virtualized network function. Cable Operator may also consider purchasing an 'all-inclusive' solution from the CMTS vendor which includes hardware, OS and vCMTS software. While this may come with a cost-premium, but Cable Operator only needs to work with 1 vendor for support and maintenance of their vCMTS platform.

Cable Operator will also need to augment their Network management and Performance management tools to include the hardware server platform and the OS. vCMTS NMS (Network management system) typically include essential alarms and platform health KPI of the server and OS, but for proactive detection and diagnostic of any developing performance defects MSOs are best to expand their network and performance management system into the hardware and OS layers as well.

4.3. Compatability with Legacy Video and other Legacy Services

In the vCMTS – DAA architecture, MSOs can support legacy QAM video services via an Auxiliary Video Core. However the integration and implementation of Legacy Video is very complicated, and requires a lot of design, engineering and/or software code development to support all legacy video services over multiple decades of Video Set-Top-Boxes. In our vCCAP program, Legacy Video service integration represented easily 50% of the time and resource for overall program integration, and MSOs should be prepared this is a very complicated integration effort.

Alternatively if MSOs do not need to deploy DOCSIS4.0 immediately, RPHY-shelf is a nice alternatively that does not require Auxiliary Video Core integration, and QAM-based video can be supported via RF combining in the headend the same way MSOs support video over i-CMTS platform today. vCMTS with RPHY-shelf will support DOCSIS3.1 Enhanced and give MSOs ~ 30-100% additional bandwidth depending on RF spectrum availability. This allows MSOs to defer the sunset of Legacy TV services until DAA uplift and DOCSIS4.0 introduction.

There may be other legacy services such as Out-of-band command and control, plant leakage etc. that require solutioning and integration. In our vCCAP program experience, all legacy services integration introduce significant complexity, and the effort to provide backward compatibility is high because of the age of these equipment platforms. If these services can be sunset or modernized, it will represent a significant reduction in integration time and effort and also Operation complexity.

5. Conclusion

Virtual CMTS is a cutting-edge technology and is an essential enabler for DOCSIS 4.0. With this new technology, it requires the Cable Operator to make architectural decisions, and also offers new architectural options which has its own pros, cons and challenges. This paper has shared some of the technical evaluations and directions that Rogers has made in our journey of vCMTS assessment, lab evaluation to field trial, and together with some Operations lessons learnt during our field trials.

Compared to evolution through previous DOCSIS generations, DOCSIS4.0 represents a much bigger network and operational transformation to MSOs. The intent is that by sharing our experience it can be beneficial to other MSOs who are navigating their paths through Virtual CMTS as well. We also hope that it encourages the MSOs and Cable industry to collaborate with tighter relationship among the MSOs and vendor communities along this exciting journey.

Abbreviations

CM	Cable Modem
CMTS	Cable Modem Terminal System
CCAP	Converged Cable Access Platform
vCCAP	Virtual Converged Cable Access Platform
RPHY	Remote-PHY
DAA	Distributed Access Architecture
PON	Passive Optical Network
OLT	Optical Line Termination
ONT	Optical Network Terminal
XGS-PON	10 Gigabits per second Symmetrical Passive Optical Network
MSO	Multiple System Operator