Migration Paths to Full CCAP Functionality

A Look at Real-Life Deployment Strategies

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Introduction

The cable industry has begun a multi-year migration toward a common platform for video and data. The technology enabling this journey is known as the Converged Cable Access Platform (CCAP). While CCAP defines a particular architecture, there are numerous ways to reach that *converged* endpoint.

How will the industry implement CCAP? The answer to that question depends on circumstances and preferences. The CCAP initiative addresses a common and urgent need to enable more narrowcast quadrature amplitude modulated (QAM) channels in a more dense and power-efficient footprint. The industry that supports this initiative is diverse; service providers have deployed several CMTS and Edge QAM architectures that rely on a range of technology suppliers and various service delivery goals.

Drawing from the real-life experience that service providers have had to date, this paper recognizes the diversity and ongoing evolution of the headend (Cloonan & Howe, 2011) and existing cable infrastructures; focusing on three paths to full CCAP:

1) CCAP Migration from I-CMTS
   For the service provider with Integrated CMTS (I-CMTS) expecting high-speed data (HSD) growth
2) CCAP Migration from M-CMTS
   For the provider using a modular CMTS (M-CMTS) and common edge QAM-based; modular headend architecture (MHA) who also expects much HSD growth
3) CCAP Migration from VOD Edge QAM
   For the provider with an I-CMTS who foresees significant video on demand (VOD) growth.

Pre-Launch: Where do you stand?

The path (or paths) taken will hinge on:

- **Network infrastructure**. Do your networks use an integrated (I) or modular (M) CMTS, or both?
- **Services roadmap**. What services do you plan to expand in the coming years? High-speed data? IP video? VOD? SDV? And what is the timing on those plans?
- **Operational strategy**. Do you plan to move quickly to the converged approach or maintain the existing architecture for as long as possible?
- **Market dynamics**. What are the bandwidth demands of your subscribers? What are the bandwidth offerings of your competitors?
- **DOCSIS 3.1**. What is your timing on migrating to the higher-capacity DOCSIS 3.1 CMTS and cable modem infrastructure?
- **Vendor timetables**. Which vendors do you work with, what paths have they taken, and what is the timing of their feature delivery?
- **Other features**. Are you concerned about the availability of other non-DOCSIS and non-Edge QAM features (such as sparing or various routing protocols)?

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Vendor Roadmaps

How service providers implement CCAP also depends on how vendors transition to this platform. That will be based on such factors as whether they are building the converged device from the starting point of the CMTS or the Edge QAM. In turn, vendors are also influenced by the feature interests and timing of the service providers to whom they hope to deliver CCAP products. One vendor may prefer to lead with DOCSIS and another with video, but service providers are likely to ask for features that do not necessarily align with a pre-determined roadmap (Tombes, 2012).

The following examples illustrate three possible migration paths to a full CCAP architecture, beginning with existing CMTS and Edge QAM implementations and allowing for video or data channel growth today.

CCAP – Past, Present, and Future

In mid-2011, CableLabs released an updated version of a technical report renaming the headend device that had been referred to previously as the Converged Edge Services Access Router (CESAR) and the Converged Multiservice Access Platform (CMAP) as the Converged Cable Access Platform (CCAP), an operationally flexible way to address the industry's pressing need for greater QAM channel density (both per RF port and per chassis) by integrating Edge QAM and CMTS functions over time.

Today, the industry is in the early stages of this multi-path migration, which could take several years to complete.

Integrating Edge QAM and CMTS functionality, however, is not necessarily CCAP's endpoint. The CCAP roadmap also includes options for passive optical networking (PON) augmentation, if so desired; optical interfaces that could involve either pluggable optical modules with traditional amplitude modulated optical transceivers or Ethernet-based remote Physical Layer (PHY) optical modules (Silbey, 2013).

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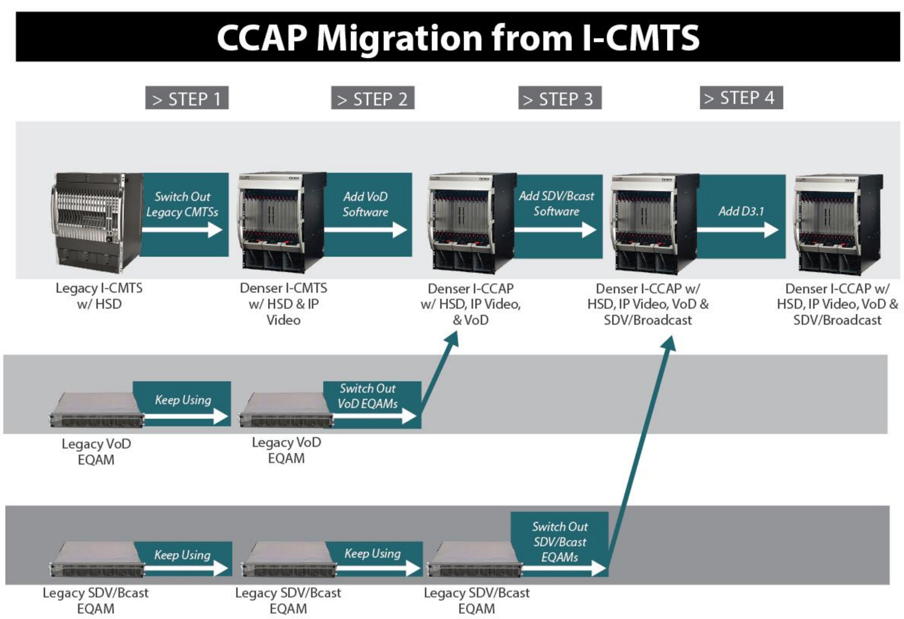
Exploring Three Migration Paths to Full CCAP

Path 1: CCAP Migration from I-CMTS

One path to full CCAP begins with a DOCSIS 3.0 I-CMTS and Edge QAM shelves that support VOD and SDV/broadcast services (see diagram below). A provider would typically feed the RF outputs from those three boxes into a combiner, feed that output into an optical transmitter, and then connect this optical output to a fiber node.

> **Step 1:** In the first phase of this migration path, the Edge QAM shelves remain the same, but the legacy I-CMTS is replaced with a denser CCAP-capable I-CMTS, such as the ARRIS E6000 Converged Edge Router.
>
> **Steps 2 & 3:** Add video functionality into the CCAP chassis, making it truly *converged*. Here, the service provider first adds VOD to the chassis, freeing up legacy Edge QAM shelves for possible deployment elsewhere in the network, and then pulls in SDV/broadcast. The end result is that the CCAP chassis carries all DOCSIS and video traffic.
>
> **Step 4:** Shows how a service provider might modify their CCAP chassis over time e.g. to add DOCSIS 3.1 functionality. Following the deployment of a CCAP-capable chassis, this step ideally is just a software load, with features enabled by licenses from the CCAP provider. However, with the significant changes to the MAC and PHY required by DOCSIS 3.1, full DOCSIS 3.1 support may require some new hardware. Either way, having *cabled once* in step two, the service provider wouldn't need to re-cable.



Rationale: *This path could be a good fit for a service provider who intends to devote resources to meet growing near-term demand for HSD services and of course, has deployed DOCSIS I-CMTS chassis.*

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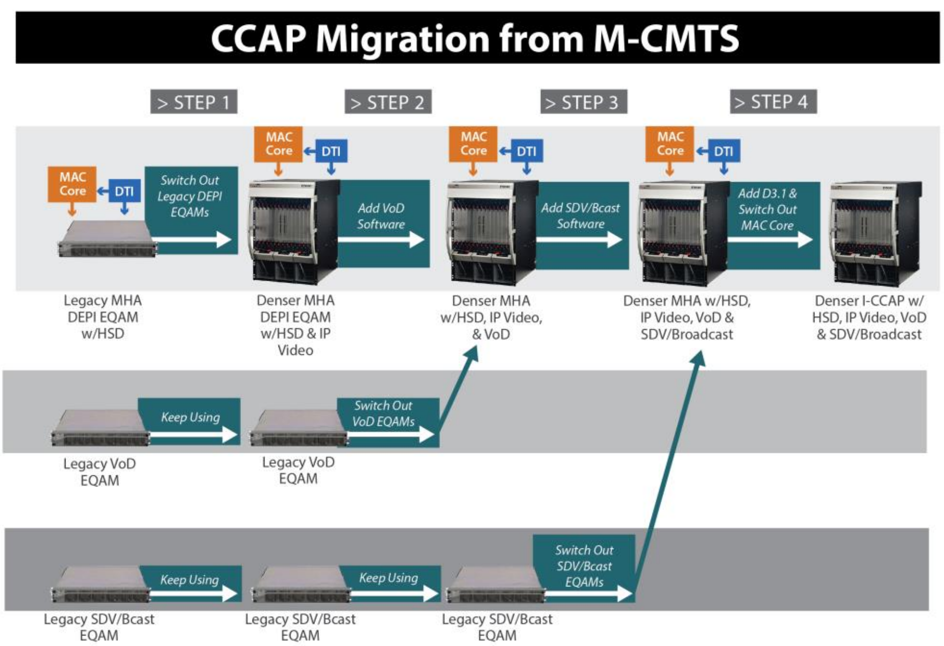
Path 2: CCAP Migration from M-CMTS

A second path involves the use of a modular headend architecture (MHA). In this case, a service provider begins with a DOCSIS media access control (MAC) core feeding a Downstream External PHY Interface (DEPI)-based Edge QAM shelf delivering high-speed data services (see diagram below). As in the first example, the starting point begins with outputs from all Edge QAM ports (high-speed data, VOD, and SDV/broadcast) feeding into a combiner and then to a downstream laser.

> **Step 1:** The service provider replaces the legacy DEPI Edge QAM shelves with a denser DEPI Edge QAM platform serving HSD and IP video. This should ultimately become a CCAP chassis, but meanwhile it can act as an Edge QAM shelf in an MHA, receiving DEPI signals from the same MAC core.
>
> **Steps 2 and 3:** As in the first example, the legacy VOD and SDV/broadcast Edge QAM shelves remain in place but can be drawn into the CCAP-capable chassis. Here, the service provider initially adds VOD and then legacy SDV/broadcast functionality.
>
> **Step 4:** Finally, the provider switches out the original MAC core while adding DOCSIS 3.1. The assumption of MAC functionality within the CCAP chassis in effect transforms this architecture from an M-CMTS to I-CMTS environment. In terms of incorporating video into the CCAP chassis, this case is similar to the previous example; the principal difference is the extended life of the legacy MAC core.



Rationale: *This scenario applies to any service provider with modular CMTS installations. What triggers the retirement of the legacy CMTS core, or its relocation to another headend, is the need to deliver more DOCSIS channels.*

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Path 3: CCAP Migration from VOD Edge QAM

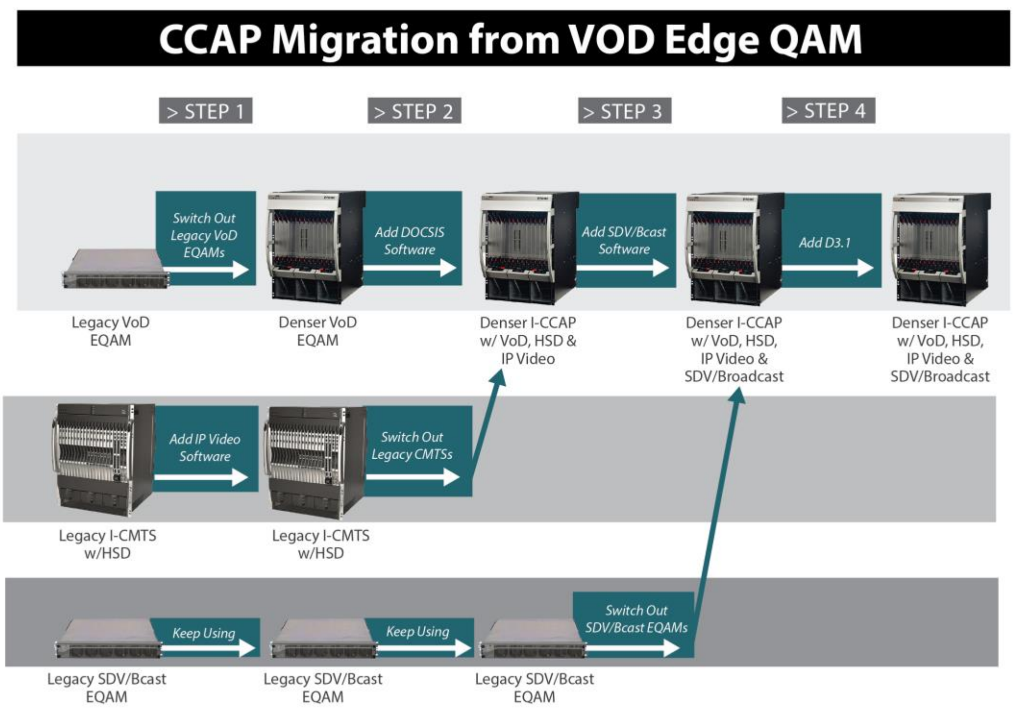
The third path builds on the VOD Edge QAM shelf instead of on the CMTS platform (see diagram below). The first step differentiates this path because the service provider is focusing on using the CCAP-capable chassis to add more VOD channels first.

Step 1: In this case, the service provider the service provider leaves the I-CMTS in place and switches out the legacy VOD Edge QAM for a denser VOD Edge QAM that resides within a CCAP-capable chassis

Step 2: After that, the provider can address the need for more HSD growth by adding upstream receiver hardware and activating the DOCSIS software within the CCAP chassis in step two, effectively switching out the legacy I-CMTS.

Step 3: Adding SDV/broadcast software enables the CCAP chassis to incorporate the functionality of the remaining legacy SDV/broadcast Edge QAMs.

Step 4: As in the other cases, the provider can activate DOCSIS 3.1 features with appropriate software and/or hardware upgrades.



Rationale: *This is another case involving I-CMTS-based DOCSIS networks. In this scenario, however, the operator foresees considerable near-term growth in VOD services.*

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Assess Your Options

These three migration examples indicate the operational flexibility of CCAP. A slightly different variant of Path 2 might have the service provider re-architecting their network from the very beginning, converting it from an MHA network into a traditional I-CCAP architecture. Another approach would be to leapfrog more directly to CCAP, possibly along with DOCSIS 3.1. Yet another path under consideration uses a non-routing (NR) CCAP, which would maintain QAM density while separating Layer 3 (L3) routing into another chassis.

Operational variations will be numerous as well. How a service provider analyzes and aligns service groups will remain ongoing work in progress. Each will adjust and revise its own set of related tools or adopt new ones as needed. The need for new cross-functional skills among DOCSIS and video teams that have until now largely operated in silos is another major challenge. Service providers may follow Comcast's lead and address CCAP's challenges to personnel, training and support systems through readiness trials (Salinger & Pearman, 2012).

Navigating today's disruptive landscape calls for careful analysis of technology and business (Torbet, Cloonan, Kraiman, Ansley, & Brooks, 2013). For the topic at hand, providers can turn to the professional services teams within the CCAP vendor community. These teams can help match each operator's unique circumstances with the matrix of possibilities available within the CCAP framework.

The bottom line is that both vendors and service providers will take many different paths on the road to full CCAP functionality. While CCAP is a technology and an architecture, it is also an evolution. Picking the right evolutionary path is critical not only for reaching the right destination, but also for ensuring that the journey matches your infrastructure, capabilities and business requirements.

What about DOCSIS 3.1?

The implementation of CCAP began before DOCSIS 3.1, but development of this latest iteration of DOCSIS has been unusually rapid. CableLabs expects the specification to be finalized by the end of 2013, with trials to follow in 2014 and commercially ready products available by late 2014 or early 2015 (Baumgartner, 2013).

Incorporation of new technology is a natural feature of the CCAP architecture. Options for pluggable optics with traditional transceivers or Ethernet-based remote PHY modules, for instance, were noted above. (See 'CCAP – Past, Present and Future.') The CCAP specifications will be expanded to include DOCSIS 3.1, and vendors have already begun to consider the incorporation of DOCSIS 3.1 into existing and new CCAP blades (Nastic, 2013).

Support for DOCSIS 3.1 in the downstream may be permitted via firmware upgrades, as many line card designs are implemented with FPGAs. On the upstream, where application specific integrated circuits (ASICS) are often utilized, new ASICS may be required. A flexible and modular CCAP architecture ensures compatibility with the spectrally efficient DOCSIS 3.1.

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Additional Resources

Visit these links for more information on CCAP deployments and solutions.

Broadband Technology Report's (BTR) video presentation of the Cable Show event, "CCAP Breakfast - Managing the Meta-Picture" where you can watch key CCAP leaders Jorge Salinger (Comcast), Mike Kelsen (Time Warner Cable), Jeff Finkelstein (Cox Communications), and Tom Cloonan (ARRIS) present their thoughts on:

- A look at trials and deployments plus how DOCSIS 3.1 merges with CCAP
- Deployment strategies for enabling CCAP to co-exist with legacy systems
- Operational aspects and winning *buy-in* from decision-makers
- Different approaches to implementing CCAP and where each makes sense

Communications, Engineering and Design (CED) magazine's recorded webcast, "Gearing up for CCAP Roll-outs"where you hear about operational and training considerations that need to be looked at ahead of CCAP deployments. This webcast covers:

- An overview of CCAP
- The transition from lab trials to field trials
- Equipment considerations that won't strand investments ahead of full CCAP rollouts
- Operational planning for possible issues among the various converged services

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List of Acronyms

CCAP	Converged Cable Access Platform—a CableLabs-led effort to develop a dense and efficient architecture combining CMTS and edge QAM modulator functionality
CMTS	Cable Modem Termination System—a DOCSIS network device that manages and communicates with many cable modems
DEPI	Downstream External PHY Interface— a DOCSIS specification that defines requirements for the transport of downstream user data between the M-CMTS core and Edge QAM
DOCSIS	Data Over Cable Service Interface Specification—an international telecommunications standard that permits Internet protocol communications transmission over a Cable TV system
Edge (E)QAM	Edge Quadrature Amplitude Modulation—a video and data network modulator with Gigabit Ethernet intput and QAM channel output; physically separate from the CMTS in a DOCSIS 3.0 modular configuration
I-CMTS	Integrated CMTS—a CMTS which contains all necessary components for DOCSIS operations
L3	Layer 3—the network layer of the OSI model of computer networking responsible for packet forwarding and routing
M-CMTS	Modular Cable Modem Termination System—a CMTS physically extended by means of Gigabit Ethernet, a DOCSIS timing server and edge QAM modulators
MAC	Media Access Control—pertaining to a Layer 2 data communication protocol that provides addressing and channel access control mechanisms
MHA	Modular Headend Architecture—CableLabs-defined interfaces for converged video and broadband services including specifications for M-CMTS and narrowcast digital video services
PHY	Physical Layer—Layer 1 of the OSI model of computer networking, consisting of networking hardware transmission technologies
SDV	Switched Digital Video—a digital video service in which channels are narrowcast (rather than broadcast) to those requesting them
VOD	Video on Demand—a digital video service for delivering movies and TV programs via narrowcast upon consumer request

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