# DOCSIS To CMAP Evolution


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## ABSTRACT


*As the need for additional video channels increases for legacy MPEG-TS delivery and new and evolving IP delivery, the amount of equipment needed to provide that new capacity may be greater than current facilities can support. Building more head-end or hub locations may be an option, but it is one of the most expensive and invasive steps that operators may undertake. As an industry, we have realized that to wait until the time you need the bandwidth is too late, and that we need to be proactive in order to be prepared for this eventuality.*

*Denser Edge QAM technologies may be used to help solve the growth from an edge perspective, but they do nothing to solve the need for more backend processing to handle the IP video streams. DOCSIS bypass has been proposed as one method for solving the IP handling and avoiding being forced to add more CMTS equipment, but in turn, DOCSIS bypass forces operators into a non-standard solution.*

*The Converged Multi-Service Access Platform (CMAP) provides the combined functionality of legacy Edge QAM, data processing of CMTS, and IP video processing. CMAP is able to provide full downstream spectrum through a single port that allows operators to have complete flexibility in deployment of services throughout the full range of channels.*

*The purpose of this paper is to discuss methods for using CMAP to solve these problems by using the new architecture as an evolutionary step in moving towards a completely converged edge solution across all services. There is no one-size-fits-all solution in this area as it crosses technology and business units, but CMAP provides a mechanism allowing each to continue managing their services as we do today and evolve into the future by incremental steps. CMAP also allows us to take a revolutionary approach and leap into the future by immediately converging services at the edge.*

## BACKGROUND

Much has been written and said recently regarding the need to leverage the more efficient delivery and lower cost features of QAM technologies in support of broadcast video, unicast video, and high-speed data services. This has led to the development of specifications that have collectively become known as the Converged Multi-Service Access Platform (CMAP) by a Comcast-led team of MSO and vendor partners.

Rather than delving into why there is a need for CMAP and of what it consists of, this paper focuses on explaining the how. In particular, we will look into the planning involved in migrating from current modular CMTS deployment to the CMAP architecture.

## PLANNING FOR CHANGE

As an industry, we strive to develop architectures that allow us to add features without requiring a complete redesign or replacement of existing equipment. While this is a good business goal, at times it does not remove the need for an equipment forklift out of necessity. We may be able to reduce the parts in need of replacement by changing out line cards, but there will be decision points for complete chassis replacements when the required capacity processed by each constituent device exceeds the backplane or overall chassis capabilities.

These inflection points tend to come at the worst possible time, which is typically when we are rolling out new services. With each new service come additional complexities in operations, administration, and management (OA&M) functions. The resulting outages caused by chassis replacement on customer service and operational effectiveness is at times devastating, and while that can be mitigated with planning and staging, the impact is real and never quite goes as expected. When dealing with chassis forklifts, Murphy is an optimist. If something can go wrong, it not only will go wrong, it likely already has but we have not noticed it as yet.

Much thought has been given to how our future needs converge video, voice, and data. IP video services, including both unmanaged over the top services and managed services, change how we view the network. We realize our service groups must come into alignment at some level as well to maximize the intrinsic value of our equipment spends. With new silicon development creating the potential to provide the entire forward path from a single port, our architectural view of the HFC ecosystem is on the verge of a paradigm shift.

With the opportunity to architect a new HFC network comes the chance to consider a new method that allows incremental changes to our existing infrastructure. We may also plan to reduce complexities inherent in our current HFC network by taking advantage of this unique opportunity in converged services. Space, power, heating, and cooling savings are key drivers as well.

The architecture must be simple and flexible in its design with built-in growth options. The cost should be significantly lower than that of existing DOCSIS solutions by leveraging technology developments via significantly improved

QAM density while maintaining hardware cost constants. Operationally, the new platform must provide us with a more reliable and manageable product that has integrated redundancy and reduces the amount of individual components being managed.

As we consider the need for this new platform, one thing becomes evident to us; it would be beneficial to leverage portions of the current architecture with deployed Modular CMTS (M-CMTS) and Edge QAM networks to reduce the complexity of transitioning to the new technology. Taking these small steps may minimize the overall impact of the new technologies.

## CMAP ARCHITECTURES

CMAP was designed to support a primary architecture of a single integrated chassis, where high-level processing and physical line cards for both downstream and upstream channels are developed in a single enclosure.

For the purpose of discussion in this paper, we are focusing on Modular CMTS and how we may utilize existing technologies to provide an evolutionary path to a full CMAP deployment.

To begin the discussion we need a background on Modular CMTS technologies.

## MODULAR CMTS BACKGROUND

In the current Modular CMTS architecture, the CMTS Core has one or more downstream network interfaces that communicate with one or more Edge QAM devices to provide the downstream channels sent to the fiber nodes for distribution to customer premises. Upstream receivers are integrated into the M-CMTS Core to simplify MAC level processing. A timing interface is required between the MAC layers contained in the M-CMTS Core and the PHY layer resident in the Edge QAM to provide the precise synchronization needed in scheduling upstream burst transmission by cable modems.

In such Modular CMTS head-ends, MSOs will continue to grow their access networks to support capacity needs for which it will be necessary to add downstream QAMs and the corresponding Edge QAM ports (in addition to new interface cards and routing/switching equipment to provide the communication path between them). We will also need to add more M-CMTS Core processing chassis' to house the new line cards needed and more Edge QAM chassis to handle the QAM modulation. It is expected that we will all optimize these purchases recognizing that not moving towards CMAP will eventually result in running out of *"brick and mortar"* space before having sufficient capacity farther down the road for future service needs.

As we on the CMAP core team discussed the alternatives, one option stood out. As the interface between M-CMTS and Universal Edge QAM was already defined within the CableLabs [MHA] specifications and had been successfully implemented by a number of vendors, couldn't CMAP also take advantage of that work?

The CMAP team discussed many of these options and decided to formally incorporate into the CMAP specification the appropriate CableLabs specification references to explicitly provide support for Universal Edge QAM functionality. This allows the integrated CMAP equipment to function as universal Edge QAM devices. By taking this step, MSOs would be able to utilize new CMAP equipment with existing Modular CMTS equipment, providing a transition roadmap from today's architecture to the CMAP future, without requiring a forklift of existing equipment.

## MODULAR HEAD-END ARCHITECTURE SPECIFICATION SUPPORT IN CMAP

There are a number of interfaces defined in the CableLabs Universal Edge QAM specifications including:

- DOCSIS Timing Interface [DTI]
- Edge Resource Management Interface [ERMI]
- Downstream External PHY Interface [DEPI], including L2TPv3 over IP, L2TVv3 over UDP/IP, MPT and PSP modes, etc.
- Edge QAM Provisioning and Management Specification [EQAM PMI]
- Edge QAM Video Stream Interface [EQAM VSI]
- M-CMTS Operations Support System Interface [M-CMTS OSSI]

While achievable, adding all the above specifications and options into CMAP might not be necessary given the original objective of adding Edge QAM functionality and would potentially add delays to the implementation timeline. As MSOs reviewed the specifications it was determined that the minimal set of M-CMTS requirements would be:

- DOCSIS Timing Interface
- Downstream External PHY Interface with MPEG Transport (MPT) support

The DTI and DEPI MPT are the primary specifications/features used by MSOs deploying modular CMTS today, and many vendors have already developed products that meet these CableLabs specifications. Therefore, it made sense to maintain that support in the CMAP specifications for the Integrated CMAP device.

## BRIDGE YEARS TO CMAP

For those MSOs that have extensive deployments of modular CMTS, we are investing in additional capacity both for CMTS and Edge QAM over the next few years to support the anticipated growth resulting from market forces. We are looking at CMAP as a long-term solution towards solving the increasing costs involved both capital and operational expenditures.

But as we work towards extending the bandwidth and capacity of our high-speed data and video services, our goal of maximizing the usable life of our currently deployed equipment is challenged by the needs of new services. We risk running out of capacity for line cards or Edge QAM devices, which will require us to add more equipment. By adding more equipment during the bridge years leading to CMAP, we are potentially making less than optimal choices on the devices we are deploying.

What we need is the new CMAP platforms available in the marketplace sooner rather than later so that we may reduce the amount of capital expenditures for new services. But, the availability of new CMAP platforms are still far enough away in time that we need to make these purchases now to provide this new bandwidth.

So what do we do?

## EVOLUTION, NOT REVOLUTION

In order to simplify the initial deployments of CMAP devices, we have been working with vendors on a downstream-only version of CMAP that some have dubbed "CMAP-lite". This allows a CMAP device to be used as a Universal Edge QAM by the CMTS core and provide a very dense solution for unicast and broadcast traffic.

While the density of CMAP functioning as an Edge QAM adds more downstream capacity for high-speed data using Modular CMTS interfaces, there is an additional benefit of higher density for video QAM channels as needed by narrowcast services e.g. SDV and VOD. Being able to leverage these increased densities for all unicast services simplifies the eventual transition to CMAP by reducing complexity in the head-end combining network.

An additional benefit is taking advantage of replication within the CMAP chassis, which delays the need for converging video and data service groups. In today's head-end architectures, we have mismatched service group sizing between narrowcast and broadcast groupings, and between video and data. The ability to replicate streams internal to the CMAP device simplifies the combining network in the head-end. Figure 1 shows an example of how using the CMAP replication feature we are able to delay alignment between data and video service groups.

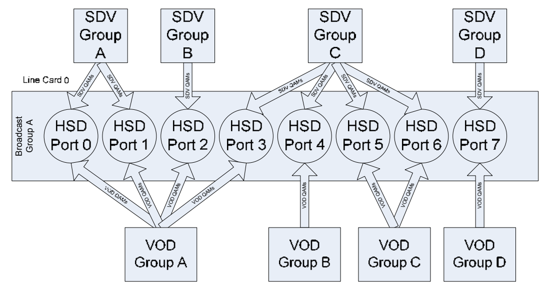


**Figure 1 - Service Replication Internal to CMAP**

## EXAMPLE ARCHITECTURAL EVOLUTION

The following figures show how an operator deploying Modular CMTS today might be able to take advantage of Modular Headend Architecture [MHA] support in CMAP. Figure 2 shows how a Modular CMTS deployment looks today. In figure 3, CMAP may be used to augment existing video Edge QAM equipment and migrate to a full CMAP deployment. Both show how CMAP may be used to add capacity for a modular CMTS deployment and begin migrating all services to CMAP.

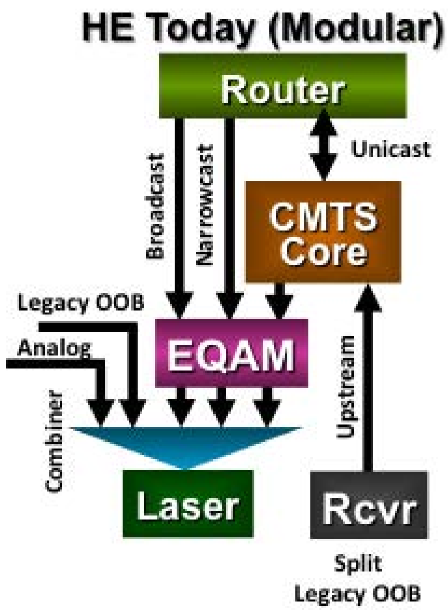


**Figure 2 - Modular CMTS Architecture Today**

As is shown in figure 2, the Edge Router sends broadcast and narrowcast video through the Edge QAM to be transmitted by the laser to the fiber node. Unicast data traffic is sent through the M-CMTS Core and down to the laser via the Edge QAM. Upstream traffic is routed through the M-CMTS Core and out through the Edge Router. All data handling is provided by the M-CMTS Core and sent to the Edge QAM for transmission to the customer.

The next few examples show methods for using an integrated CMAP for providing Edge QAM like services.

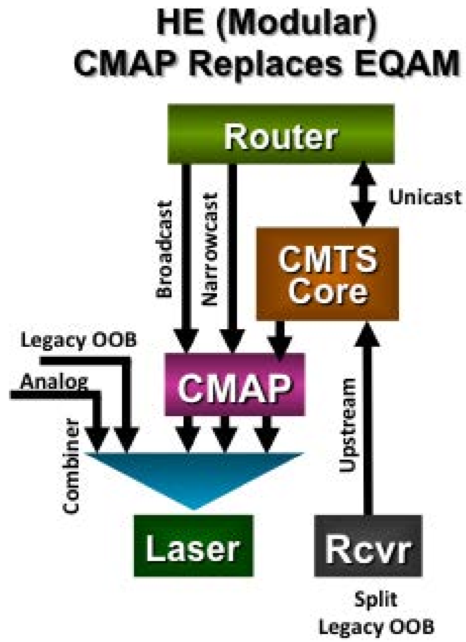


**Figure 3 - CMAP replacing existing Edge QAM**

In figure 3, using CMAP as an Edge QAM provides for denser QAM deployments without requiring any changes in the DOCSIS network. This allows growth in downstream capacity for both video and data services without impacting the M-CMTS Core devices deployed in Modular CMTS head-ends being used today.

If we need to scale legacy video, instead of adding more Edge QAM devices, we may simply reassign QAM channels to video services. If more data channels are required, we can do the same reassignment.

## MOVING TO A FULL CMAP SOLUTION

At this point we can now replace the M-CMTS Core with CMAP to take over the routing and high level MAC processing. The CMAP device now becomes an integrated CMTS core and Edge QAM all in one chassis by having all linear video, narrowcast video, and data traffic sent to it by the edge router.

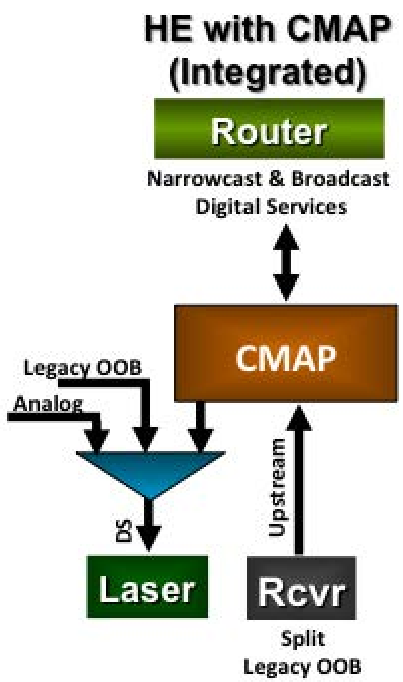


**Figure 4 - Integrated CMAP Fully Deployed**

Figure 4 shows how an integrated CMAP may be used to provide all capacity for narrowcast and broadcast services, whether video or data. This step is taken when the capacity provided in figure 3 has exceeded the CMTS core device capacity and would require more equipment to be installed.

We have now removed all existing legacy video and data equipment from the traffic path. Benefits to this architecture are many, the most significant being the power, heating, cooling, and rack space savings realized by replacing multiple video and data equipment by a CMAP chassis.

## CONCLUSIONS

The CMAP platform provides the next step in access technology evolution. As it provides for full forward spectrum from a single connector, most head-end wiring and resulting complexity become obsolete. With all services including SDV, VOD, broadcast and HSD provided from a single edge device, the points of management in the network are reduced. Environmentally floor spaces, power consumption, UPS capacity, heating, and cooling savings are significant.

The challenge that MSOs face with CMAP is one of evolution toward deployment without having to revolutionize their network and headend design to take advantage of this next step in the access network technology life cycle. By taking advantage of the work done to date by CableLabs and the CMAP team, vendors and MSOs are able to provide a transition for the bridge years by using CMAP as a super dense Edge QAM while progressively retiring existing equipment to optimize expenditures prior to a broad deployment of CMAP. This simplifies the transition and allows services to be migrated as needed, which improves capabilities of the current spend in providing a longer usable life for equipment being deployed today.

## ACRONYMS

BC: Broadcast
CAS: Conditional access system
CLI: Command line interface
CMTS: Cable modem termination system
dBmV: Decibel referenced to millivolt
DOCSIS: Data over cable service

interface specification
DRFI: DOCSIS radio frequency interface
FPGA: Field programmable gate array
GHz: Gigahertz
GigE: Gigabit Ethernet
HE: Headend
HFC: Hybrid fiber-coax
HSD: High-speed data
MAC: Media access control
MCX: Multi commodity exchange
MHz: Megahertz
MPEG: Moving Picture Experts Group
MSO: Multiple system operator
NC: Narrowcast
OA&M: Operations, administration, and management
OTN: Optical termination node
PHY: Physical
PMI: Provisioning and management interface
PON/EPON: Passive optical network/Ethernet passive optical network
QAM: Quadrature amplitude modulation
RF: Radio frequency
RFI/RFQ: Request for information/request for quote
SCTE: Society of Cable and Telecommunications Engineers
SDV: Switched digital video
SNMP: Simple network management protocol
VOD: Video on-demand
VSI: Video stream interface
XML: Extensible markup language

## REFERENCES


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**[DTI]** DOCSIS Timing Interface Specification, CM-SP-DTI-I05-081209, December 9, 2008, Cable Television Laboratories, Inc

**[ERMI]** DOCSIS Edge Resource Manager Interface, CM-SP-ERMI-I03-081107, November 08, 2007, Cable Television Laboratories, Inc.

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