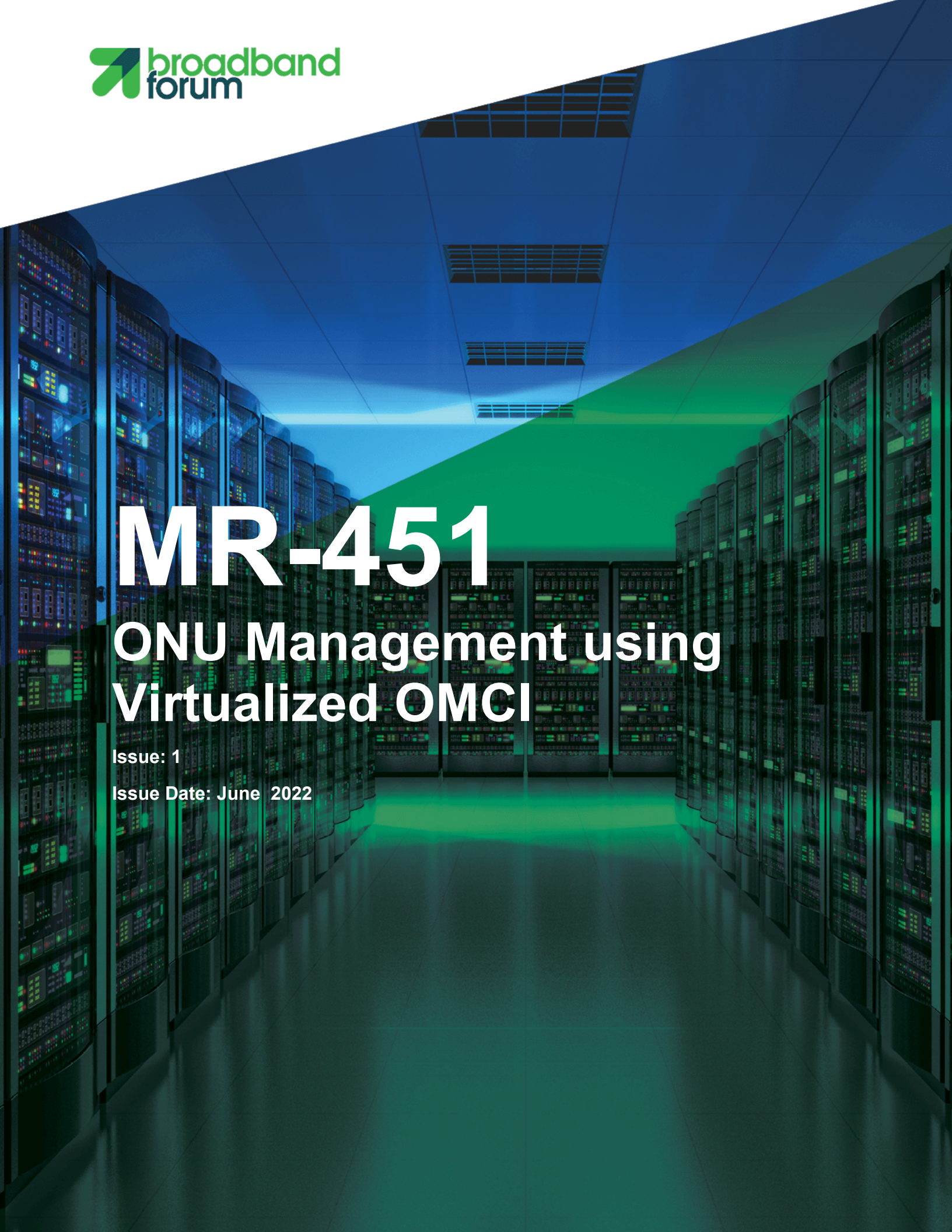

MR-451

ONU Management using Virtualized OMCI

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Table of Contents

List of Figures

Executive Summary

The Broadband Forum (BBF) has defined a specification, TR-451, that provides the architecture, requirements, and interface specifications for a virtualized OMCI (vOMCI) solution that moves the OMCI functionality used to manage an ONU (Optical Network Unit) traditionally embedded within Optical Line Termination (OLT) network elements into the Operator's network. This movement gives Operators and Service providers more flexibility in how they create, activate, and maintain services associated with ONUs. Likewise, the vOMCI solution enables easier interoperability testing and on-boarding the ONUs within the Operator's ecosystem and network.

The vOMCI solution specified by TR-451 supports various deployment models of the vOMCI solution where functions (i.e., OMCI translation function, OLT & ONU management functions) can be deployed as virtualized network functions and are expected to be used within Access domain SDN management and control solutions (e.g., Broadband Forum's CloudCO, vOMCI-as-a-Service offering) or as a stand-alone process that can be deployed with existing management system solutions.

This paper describes the business motivation for virtualization of the ONU management using OMCI and BBF standardization work on the Requirements, Architecture, Interfaces, and Protocols.

1 Virtualization of ONU Management Introduction

In 1998, the FSAN group started to define how ONUs can be brought online within the Operator's management plane. At the same time, the DSL Forum (later the Broadband Forum) and IETF were working on different protocols and MIBs to provide the management of CPEs. This work resulted in the ITU-T defining the ONU Management and Control Interface (OMCI) for ATM-PON systems that was later used for the basis of the ITU G.988 OMCI specification for xPON systems. The OMCI work in the ITU-T resulted in a Layer-2 management interface between the OLT and ONU where the OLT acted as the master management entity toward the ONU that now represent a slave managed entity. In this architecture, the expectation was that the OLT would provide a mediation function between the MIBs and protocols defined by the DSL Forum and the IETF. This relationship led to the use of the OLT to host embedded ONU management mediation logic, tying the management lifecycle of the ONU to a specific vendor's OLT. With advancements in cloud-based technologies, the ONU management and control interface can be disaggregated from the OLT into the Operators network, alleviating the tight coupling of the management lifecycle of the ONU solution with the OLT solution.

The Broadband Forum's TR-451 open standard and specification enables network operators to de-couple the ONU and OLT from control and management purposes. TR-451 introduces vOMCI as a solution to centralize these operational and functional requisites without relying on each OLT to act as a management entity.

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2 Business Motivations

The disaggregation of the management and control for the ONU from the OLT resulted in the following benefits:

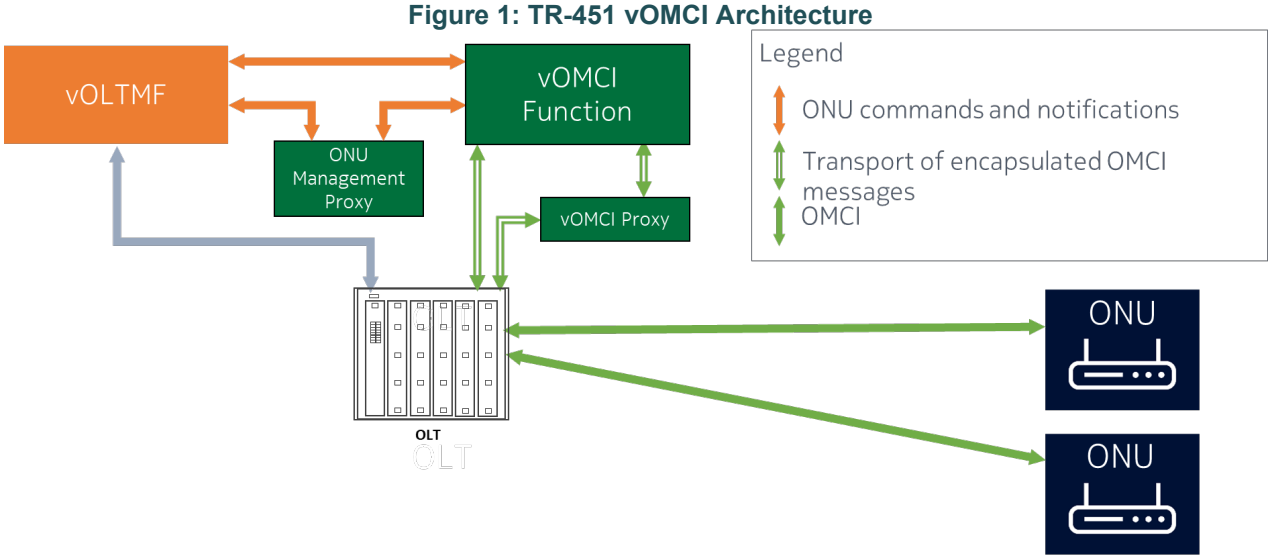
- Reduces the time and costs to onboard new ONU vendors, as the Operator's OLT vendors (at least 2) no longer needed to be intimately involved in any roll-out for the management of services and features provided by the ONU.
- Reduces the time needed to roll-out services as well as costs to maintain ONUs by removing the artificial coupling that tied the operational improvement and maintenance cycle for ONUs to the software cycle of their OLT(s) vendors.
- Increases the number of potential ONU vendors that are different from the Operator's OLT vendors, thereby allowing the Operator to better negotiate the best prices for ONUs.
- Increases the Operator's capability to migrate and evolve their network by applying new innovations and flexibility in deployment options in the FTTH core and edge delivery network (e.g., Whiteboxes, SDN/NFV, vOMCI-as-a-Service) in the management of devices to ONUs in a timely, cost-effective manner.
- Increases the Operator's ability to have specialized work-flows to account for implementation decisions that differ between ONU vendors.
- Increases the Operator's ability to use the ONUs from the operator's tenants in Fixed Access Network Sharing (FANS) and other open network deployments.

The development of TR-451 addressed all the limitations noted above. Another motivation that TR-451 assured was the existing deployments and the Operator's investment in their existing ONU devices continue to be maintained. TR-451 is a specification that is used in the evolution of the management of ONUs, not a replacement for the management processes and data models already in use by the Operators.

3 vOMCI Architecture and Interfaces

The Broadband Forum's TR-451 specification addresses each of the side effects as well as the migration and co-existence concerns described in section 2; ultimately making the management of ONUs more adaptive to changes in the Operator's processes and services, and less costly to maintain. This section describes the TR-451 architecture and provides explanations for how the architecture addresses the various business motivations.

Figure 1: TR-451 vOMCI Architecture



The vOMCI Architecture is comprised of the following required components:

- **ONU:** The ONU's behavior in TR-451 remains the same as it is specified in ITU G.988. Because operationally the ONU's control and management interface remains untouched, the Operator's existing capital investments in ONUs are retained, and avoids new/additional costs associated with deploying ONUs that are migrated from today's ONU management infrastructure to the more flexible TR-451 cloud based SDN infrastructure.

- **OLT:** While the ONU's behavior remained the same, the OLT's involvement is greatly reduced in TR-451. In existing deployments, the OLT is both the communication endpoint for the ONU management and control (OMC) communication channel, and the OLT also provides the logic to manage the attached ONUs. While the OLT still retains the role of the OMC communication channel endpoint, the ONU management logic is moved from the OLT to the vOMCI Function. In its place, the OLT now provides a communications proxy function that relays OMCI messages between the ONU and the vOMCI Function or vOMCI Proxy.

  As part of the migration toward management of ONUs using vOMCI, OLTs are upgraded to provide this new communications proxy functionality along with its existing ONU management client during the migration of the management client for ONUs that are attached to the OLT. The TR-451 specification was developed such that it uses the same message transport (i.e., gRPC), encoding protocols (i.e., GPB) and YANG management models used to disaggregate control plane functions as specified in WT-477.

> **Note:** WT-477 is an in-progress Working Text (WT) of The Broadband Forum. See the Work In Progress Wiki page for current ongoing work and the Technical Reports (TRs) webpage for approved work.

Because the OLT's role in the management of the ONUs was previously limited, the management lifecycle for ONUs is now largely decoupled from software lifecycle of the OLT, enabling faster service roll-outs toward ONUs as well as reducing the costs to onboard and maintain ONUs. Additionally, now Operators can more cost effectively add new ONUs to their networks.

- **vOLTMF:** The vOLTMF provides the logic needed to manage an ONU as well as provides an authoritative YANG representation of the configuration and state information for ONU to other management systems. To perform this function, the vOLTMF uses and orchestrates information received from the OLT (e.g., PLOAM state notifications) as well as the vOMCI function.

- **vOMCI Function:** The vOMCI Function responsible for maintaining the OMCI master capabilities for managing an ONU's OMCI MIB that includes items like maintaining the synchronization with the ONU's MIB configuration and alarms, mediating the OMCI ME (define) data and operations with the YANG based commands, responses and notifications of the vOLTMF.

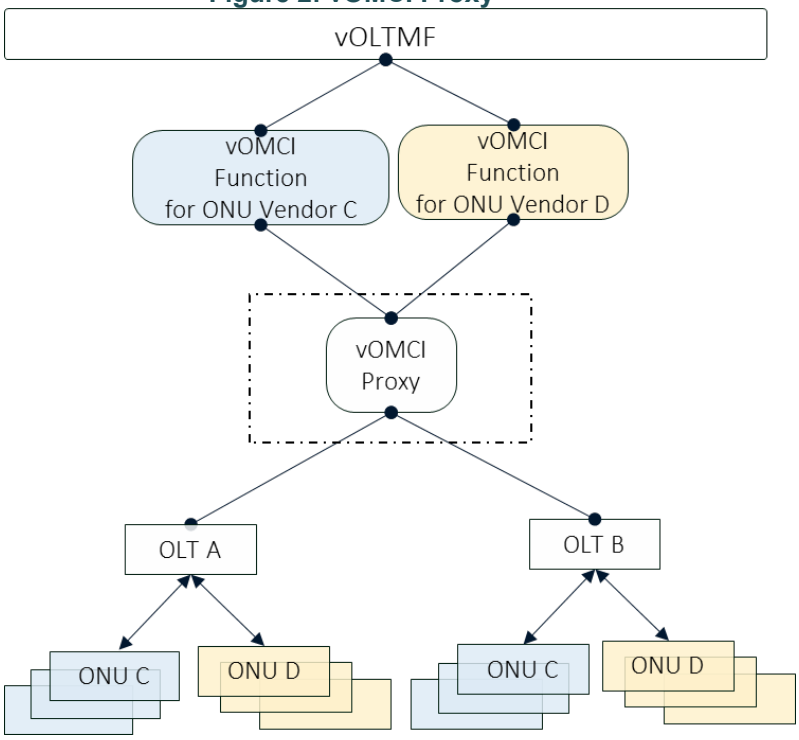
  Separating the vOMCI Function from the vOLTMF provides the scalability needed to manage and synchronize the large number of ONUs deployed in an Operator's network while adapting the different and varying implementations of OMCI MEs and the associated logic among different ONU vendors and even different ONU models within a vendor. Additionally, the separation of the vOMCI Function from the vOLTMF permits Operator's to easily add new adaptation logic for new services and ONUs into their network.

Depending on the Operator's use of the vOMCI solution, the following optional components of the vOMCI Architecture can be used:

- **vOMCI Proxy:** In Operator networks, the different deployment locations and lifecycles of instances of vOMCI Functions can increase the number and frequency of changes to the connections between OLT and the vOMCI Function instances used to manage the ONUs attached to the OLT. In these deployments, Operators can lessen the burden on the OLT by deploying a vOMCI Proxy between the OLT the vOMCI Function instances. The vOMCI Proxy acts as a stable aggregation point from the view of the OLT where the OLT always connects to the vOMCI Proxy thereby reducing the burden both in resources and number of configuration changes needed in the OLT.

  In Figure 2 the vOMCI Proxy is used to aggregate connections to vOMCI Functions for ONU Vendors C and D.

Figure 2: vOMCI Proxy

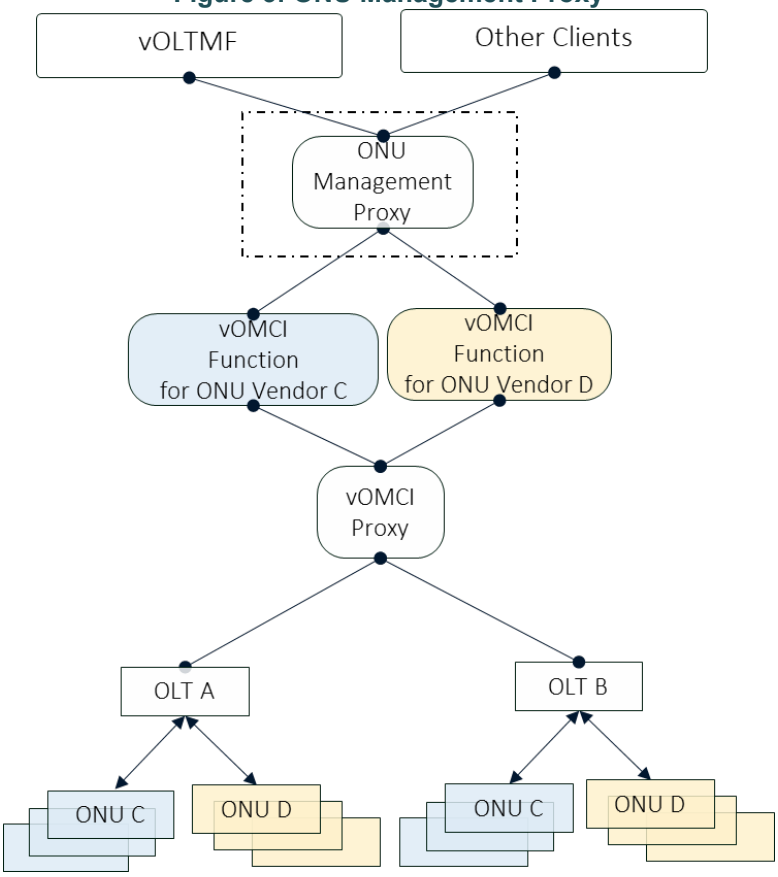


Additionally, because vOMCI Functions can be deployed in various locations, the vOMCI Proxy can be used as a monitoring/interception point in the Operator's network to inspect and modify vOMCI message flows between the vOMCI Function and the OLT.

As the vOMCI Proxy is an aggregation, monitoring/interception point the vOMCI Proxy can isolate changes of the vOMCI solution from the OLT and ONU, deploying different types of vOMCI solution deployments (e.g., SDN-based, vOMCI-as-a-Service) that are less expensive to maintain.

- **ONU Management Proxy:** The ONU Management Proxy can optionally be deployed to act as a stable aggregation point from the view of the vOLTMF function and other clients in vOMCI-as-a-Service deployments when ONU management is offered as a Service to various clients within the Operator's network. The ONU Management Proxy isolates the client applications from changes to connectivity of instances of vOMCI Functions that makes vOMCI-as-a-Service deployments less expensive to maintain. In Figure 3 the ONU Management Proxy acts as an aggregation point between the vOMCI Functions for ONU Vendors C and D for various clients such as the vOLTMF.

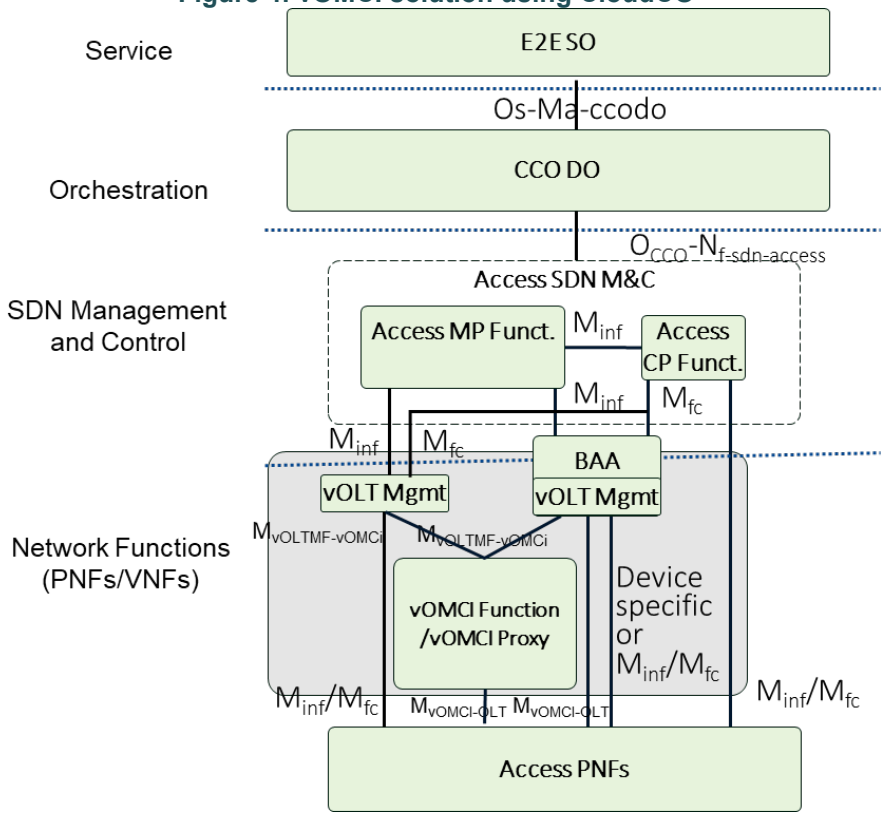
Figure 3: ONU Management Proxy



4 vOMCI Deployments

TR-451 describes how the components of the vOMCI solution can be deployed within various architectural frameworks. This includes SDN-based architectures such as CloudCO as depicted in Figure 4.

Figure 4: vOMCI solution using CloudCO

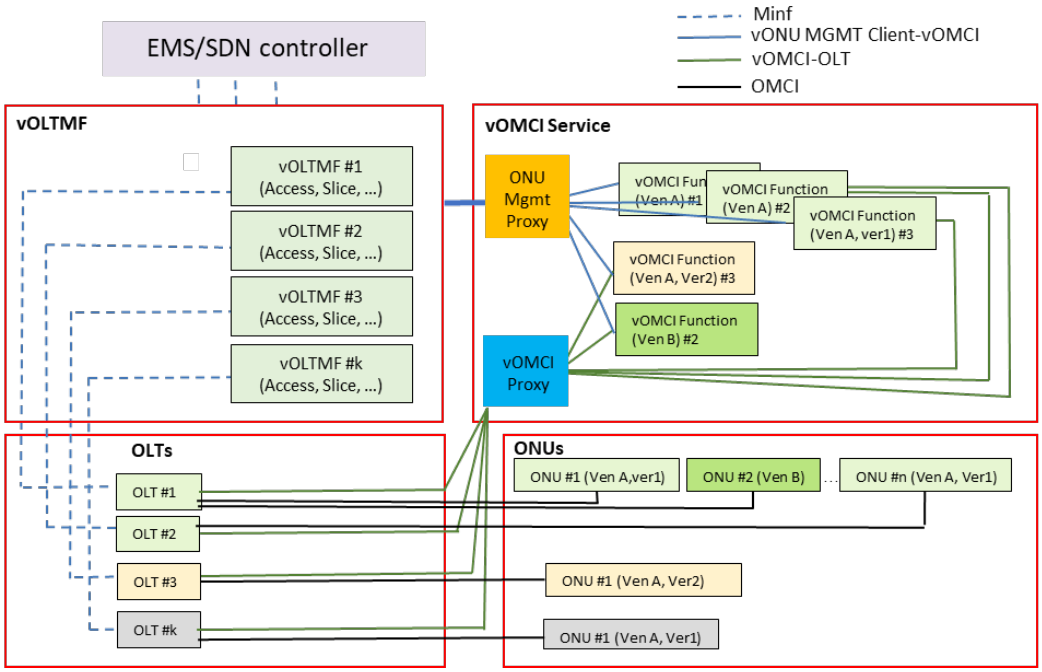


In CloudCO deployments, the vOMCI Function and/or vOMCI Proxy can be co-located with the BAA Layer at the Central Office sites or can be deployed in the Central/Regional datacenters with the Access SDN M&C function. Deploying the vOMCI solution within the CloudCO has the following benefits:

- The vOLTMF is able to provide an authoritative source of truth for the management of ONUs.
- The placement of the vOMCI Function and vOMCI Proxy within the Operator's network isn't restricted by the architecture; instead, the placement of the functions is solely dependent on the application behavior (e.g., latency requirements for OMCI message processing).

The vOMCI-as-a-Service deployment organizes the ONU Management Proxy, vOMCI Proxy, and vOMCI function entities into a vOMCI service that is consumed by multiple client instances within the vOLTMF that is in charge of the various management functionalities such as ONU access and slice management as depicted in Figure 5.

Figure 5: vOMCI-as-a-Service



Deploying vOMCI-as-a-Service has the following benefits:

- When the scaling behavior of the vOMCI function instances rapidly changes (e.g., during restoration of a geographic outage) and/or the number of vOMCI function instances needed to manage the ONUs is large, the vOLTMF and OLT instances are no longer affected. Instead, the burden of interactions toward the vOMCI function instances is contained within the vOMCI service and its ONU Management Proxy and vOMCI Proxy entities.
- Simplification of the clients consuming vOMCI services such as vOLTMF instances is accomplished by relying on the ONU Management Proxy to maintain the connectivity to the vOMCI function instances and also provide the capability of allocating ONUs to vOMCI function instances.
- Monitoring and management of the vOMCI function instances can be more effectively performed by the vOMCI service as the vOMCI function instances are scaled and maintained and ONUs are re-allocated between vOMCI functions instances.

The benefit makes vOMCI-as-a-Service a good deployment choice when the Operator requires a large number of vOMCI function instances that are frequently instantiated or deleted in order to manage the Operator's ONUs.

5 The Need for an Open Approach and the BBF's Role

The Broadband Forum Open Broadband projects and certification programs provide a venue that makes a significant contribution to assist the realization of open, multi-vendor software-defined access networks (SDAN). The key role of the Broadband Forum and other similar bodies is to encourage a standardized approach so that fully interoperable, large-scale deployment can occur economically. The BBF's Broadband Access Abstraction initiative (OB-BAA) provides a reference software implementation of the TR-451 vOMCI solution that gives developers a significant advantage of developing implementations for various components that make up the vOMCI solution. The latest release of OB-BAA project can be found here.

6 Terminology

6.1 References

The following references are of relevance to this Marketing Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Marketing Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

Document	Title	Source	Year
[1] TR-451	*vOMCI Specification*	Broadband Forum	2022
[2] WT-477	*Cloud CO Enhancement - Access Node Hardware Disaggregation*	Broadband Forum	TBD
[3] G.988	*ONU management and control interface (OMCI)*	ITU-T	2017

6.2 Definitions

The following terminology is used throughout this document.

vOMCI Virtualization of the OMCI functionality within the PON Access Network

vOMCI Function	A function in the vOMCI solution that is responsible for the translation of ONU management requests, response, and notification between OMCI messages and YANG objects.
vOLT Management Function	A function in the vOMCI solution that is responsible for the management of the PON Access Network that includes management of ONUs and OLTs. ONUs can be managed using the vOMCI solution or through the OMCI solution embedded within the OLT.

6.3 Abbreviations

This document uses the following abbreviations:

ATM	Asynchronous Transfer Mode
BBF	Broadband Forum
DSL	Digital Subscriber Line
EMS	Element Management System
FANS	Fixed Access Network Sharing
FSAN	Full Service Access Network
GPB	Google Protocol Buffers
gRPC	Google RPC
IETF	Internet Engineering Task Force
MIB	Management Information Base
OB-BAA	Open Broadband Broadband Access Abstraction
OMCI	ONU Management and Control Interface
ONU	Optical Network Unit
OLT	Optical Line Termination
PLOAM	Physical Layer Operations, Administration and Maintenance
PON	Passive Optical Network
vOLTMF	vOLT Management Function
SDAN	Software Defined Access Network
SDN	Software Defined Network
WA	Work Area
WT	Working Text

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