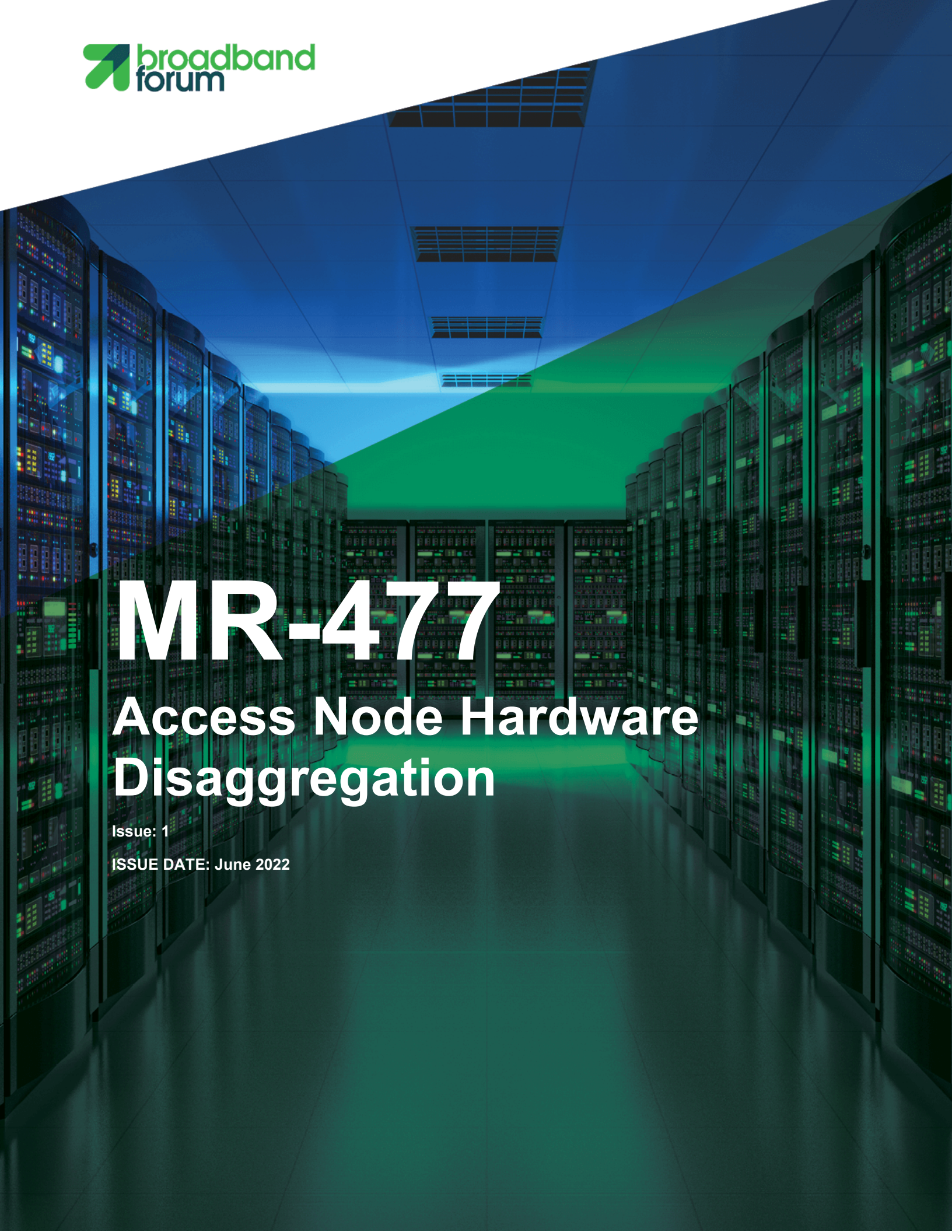

MR-477

Access Node Hardware Disaggregation

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Executive Summary

Broadband Forum (BBF) has defined the architectural framework, interfaces and requirements for the disaggregated broadband central office in the CloudCO series of technical reports, starting with TR-384, Cloud Central Office (CloudCO) Reference Architectural Framework [1].

Importantly, the migration options from legacy networks towards a CloudCO compliant solution was further presented in TR-408, CloudCO Migration and Coexistence[2], and paved the way for the definition of a cloud-native disaggregated Access Node to become a reality that this whitepaper presents.

The Disaggregated Access Node Working Text extends the principle of disaggregation between the control and user planes[1] onto the Access Nodes themselves, e.g., an OLT in a fibre network. In effect, we are disaggregating control and management plane functions from the Access Node so that these can become virtualized functions within the CloudCO. In doing so, we introduce flexibility in the deployment of the management and control plane, allowing for the independent deployment of user plane components, e.g., the OLT, and the management and control planes.

By extending the principles of disaggregation and using whitebox hardware and software solutions to the Access Node, we also enable the ability for new Cloud Central Office applications and services to incorporate the inherent computing potential of this component at the edge of the network, delivering a truly distributed solution orchestrated from a single, unified, and standards-based management and control plane.

This paper describes the business motivation for Disaggregated Access Nodes and Broadband Forum standardization work on the requirements, architecture, interfaces, and protocols.

1 Access Node Hardware Disaggregation Introduction

The Access Node in a Broadband or any other Network is the critical element that processes incoming requests for authentication and is responsible for processing data packets once the connection is established for a customer. As such, all related control, management, and data plane traffic flows through the Access Node in one way or another. The Access Node is the element inside the service providers core-network that implements the specific technology-specific protocols, for example DSL, G-PON, XGS-PON, and future evolutions of network connectivity. It is also the first point of aggregation of the so called “last mile” and the density of deployment of Access Nodes is directly proportional to the overall achievable coverage for the various markets, be their consumer or enterprise domains.

Broadband technologies have evolved at pace and whilst this represents progress, it also adds pressure on the Service Providers in their need to protect their (deployment) investment to ensure profitability before the previous generation of technologies, which traditionally would also require a new cycle of software deployment, needs to be introduced to address customer requirements for better quality of service, higher speeds, lower latency and other characteristics. Access Nodes themselves are evolving to separate the layer 1 protocols from the more stable higher layers network (e.g., Ethernet), transport and application protocol suites which increasingly are IP-based. Disaggregating the Access Node hardware solutions from the associated software stacks protects investment in the latter and, by virtue of reuse of the prior deployment, accelerates the transition to new layer technologies.

The BBF Software Defined Networking and Network Functions Virtualization (SDN and NFV) group has been working in this project to revolutionize the architecture of the Access Node to address the changing needs of industry. Disaggregated Access Nodes implement the de-coupling of control, management, and user plane functionality and, in addition, the physical hardware of choice from the onboard software that delivers those functions, allowing the service providers to choose from multiple third-party developed software and, increasingly, the option of Opensource community developed and supported protocols stacks. This definition is coming together in the WT-477[3], which will be publicly available when completed.

2 Business Motivations

Diversification:

Diversification in the supply chain for hardware and software solutions is a strategic direction in many markets across the world, with a key focus on increasing the number of product and solution providers, facilitating the removal vendor-lock, and promoting competition.

Disaggregation of control and user plane, alongside whitebox hardware and software solutions, enables diversification by allowing the eco-system of suppliers to grow where new players, from the IT domain for example, can enter the telco market and provide solutions alongside traditional telco vendors. Service providers can thus be more selective in their supplier choice for individual aspects of the solution, as opposed to necessarily only considering those capable of providing a complete end-end solution. At the heart of disaggregation is the reduction of Capital expense (CapEx) and Operational expense (OpEx), which is achieved by increasing competition and removing vendor lock-in through an increase in the eco-system of suppliers for each component of the end-end solution.

OPEX savings:

Critically, Disaggregated Access Nodes advantage is their ability to simplify operations significantly, through automation and integration through standards-based interfaces. The management of Access Nodes from multiple suppliers with different software implementations and technology support can be greatly simplified by using a single, common, software-defined central office such as those offered by CloudCO compliant

implementations. Introducing new vendors and new technologies further promote the growth of the “plug and play” paradigm, removing manual steps and, increasingly, the need for engineers to visit customer premises to perform service activation.

Introducing flexibility in the supply chain, and choice of implementation in a multi-vendor environment, needs to be carefully engineered and managed as increasing the number of components, and associated suppliers, required to deliver an end-to-end service, has the potential to make the end-end solution more complex and costly.

To mitigate against the introduction of additional complexity, the use of open and standardized interfaces coupled with compliance to interoperability in the implementation may not be sufficient: automation of workflows, configuration and maintenance tasks is a critical activity to go alongside the deployment of disaggregated solutions.

Eliminating or reducing manual operations is a critical success factor that needs to be met to accomplish a reduction in OpEx, allowing coverage and capacity growth on the user plane to be managed independently of capacity growth in the management and control plane, as promoted by the multi-vendor, multi-technology CloudCO architecture.

CAPEX savings:

Legacy Access Nodes typically require a complete hardware upgrade, as well as an upgrade to software, when a new physical layer access technology is introduced, which can render the component obsolete. Disaggregation allows for a clear separation of hardware from software, allowing hardware suppliers to design plug-and-play replaceable hardware components, such as SFPs, and in doing so, further reduce the potential for premature obsolescence. Decoupling the Software from the Hardware solution allows flexibility in that reliance on the supplier of the software to perform upgrades is removed: Software upgrades become an automated, continuous, vendor-decoupled process.

With disaggregation, software upgrades for CP and UP can be managed separately: Changes to the control plane do not affect the UP and vice-versa, so that there is less of an impact on the end-end availability of the service during maintenance.

The Disaggregated Access Node solution offers an entirely new deployment paradigm:

1) A choice to scale only in either of the CP or the UP
2) A choice in choosing the platform to host the CP or the UP
3) Independent CP or UP hardware upgrades

In addition, Disaggregated Access Nodes are increasingly rich in processing power and as such, as well as the traditional control and user plane functions, can provide virtualization support and hosting a number of functions or services, potentially turning the hardware platform into an “Edge Computing” resource. Examples of such functions include ONU Authentication, Traffic Steering, vOMCI, and others, which could be hosted on a suitable Disaggregated OLT or indeed on a centralized CloudCO platform. Such flexibility affords service providers with different deployment options to address their needs. In a typical network deployment, the Access Node deployment can be as high as 70% of the overall deployment cost. Reducing unit cost, increasing the lifetime of individual components, and the ability to isolate upgrades without having to change the control plane functions provides a massive advantage to service providers.

Multi-vendors inter-operability:

Standardization of Disaggregated Access Node architecture, interfaces, and protocols allows interoperability between vendors’ control plane and user plane elements. Service Providers can compare different products and leverage a multi-vendor environment for financial or technical advantages. Vendors, on the other hand, can be assured of one-time development cost with the standardization of Disaggregated Access Node architecture, interfaces, and protocol.

Technology assurance:

For operators of converged networks especially, Disaggregated Access Nodes are equipped with Layer 1 SFP ports which provide a level of future proofing. The ports themselves can host ethernet SFPs on the backhaul side and multiple layer 1 standards on the access (customer) side; for example, G-PON, XGS-PON, and in many cases, “Combo” SFPs which can support both at the same time. But the control plane features and mechanisms remain largely the same, limiting any differences to KPI characteristics such as bandwidth and any additional parameters which are required by different technologies.

Time to deliver new service:

The Disaggregated Access Node integration to a common, centralized control plane function provides a single point for service provisioning. New service offering can be expediently rolled out to all subscribers, improving the time to market and market reach. Building on the technology assurance use case, the above example of a new service is a PON technology upgrade which could be implemented by simply replacing the SFPs within the same OLT chassis to deliver a higher speed service. In this case, we would replace the G.PON SFP by an XGS-PON and also replace the customer premises equipment, the ONT, into XGS-PON. No other hardware or software changes should be necessary within the rest of the network and operations, i.e., the same centralized Cloud Central-Office based, management and control plane and operational processes can be used to affect this new service introduction, reducing time-to-market.

Edge Computing potential:

The disaggregation of the hardware from the software solution also enables virtualization of the computing power, which is also present in the Access Node hardware, as it is within the central office. Such a virtualization capability, through technologies such as Openstack and Kubernetes, opens the potential for the Access Node to become part of an Edge Computing deployment, where additional applications can be instantiated, alongside the user plane features which are mandatory to have. The Access Node can thus become another resource available for orchestration by Cloud Central Office.

3 Access Node Hardware Disaggregation Architecture and Interfaces

The Access Node Hardware Disaggregation[3] project focuses on separating the hardware solution from the software stacks for management, control and user plane feature-set. In addition, Disaggregated Access Node adhere to Southbound Interface that meet the requirements of the CloudCO architectural framework and interface definitions incorporating in the process of developing the specification concepts from open-source solutions.

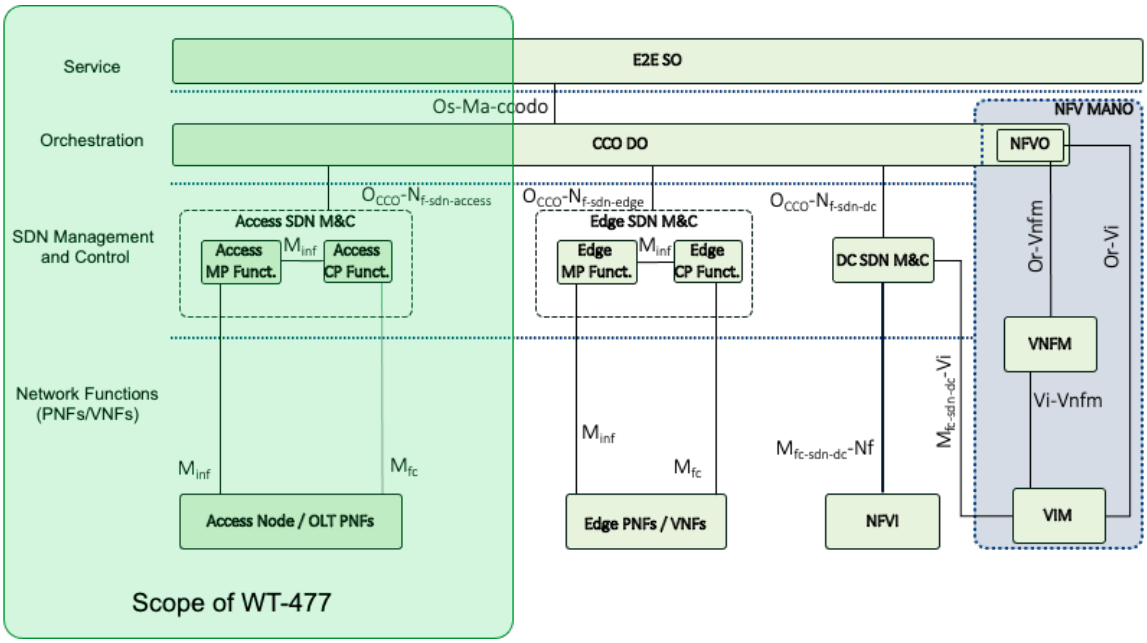

Figure 1: Cloud-Central Office framework

Figure 1 shows the Cloud Central Office Architecture, with the Access Node integration via the Minf and Mfc interfaces for management and control.

The extension of CloudCO architectural principles of disaggregation and the introduction of the whitebox solution for Access Nodes has an impact in how the disaggregated Access Nodes integrate into the centralized management and control plane. Taking the Access SDN M&C component, alone we can see the Disaggregated Access Node (D-OLT using an OLT as the example) in Figure 2. The interfaces Minf and Mfc between Access SDN M&C and D-OLT and Access Node / OLT are already defined in TR-411[4], and TR-413[5].

The goal of this activity is to define the interface Mfc between Disaggregated OLT (D-OLT) and Access Node / OLT. The Mfc interface will do three different actions according to the function to be virtualized:

- **Management Interface (Mfc_Minf)**: The D-OLT will manage its associated Access Nodes / OLTs and is responsible for pushing configurations and retrieving operational state and status to and from the Access Node / OLT.
- **Control Packet Redirect Interface (Mfc_CPRi)**: This interface is required to forward and tunnel control packets such as DHCP and PPPoE between D-OLT and Access Node / OLTs.
- **State Control Interface (Mfc_SCi)**: This interface is used to program a default rule to redirect control packets between user plane and control plane. After the traffic rules are programmed onto the Access Node / OLT, the Access Node / OLT will forward the subscriber data traffic according to the rules.

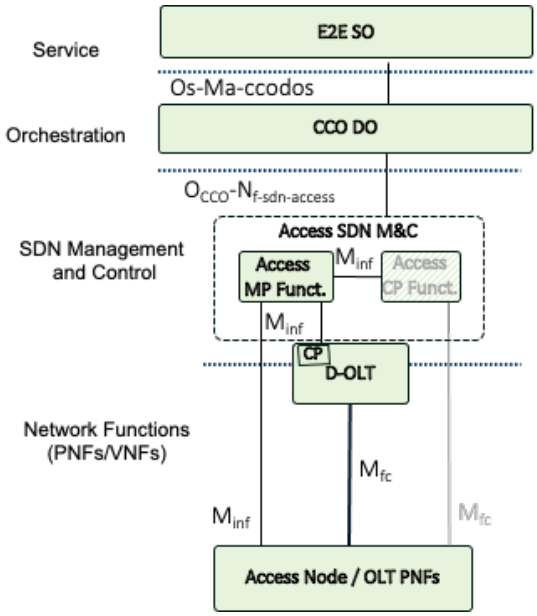

Figure 2: Disaggregated OLT as an example Access Node in CloudCO framework

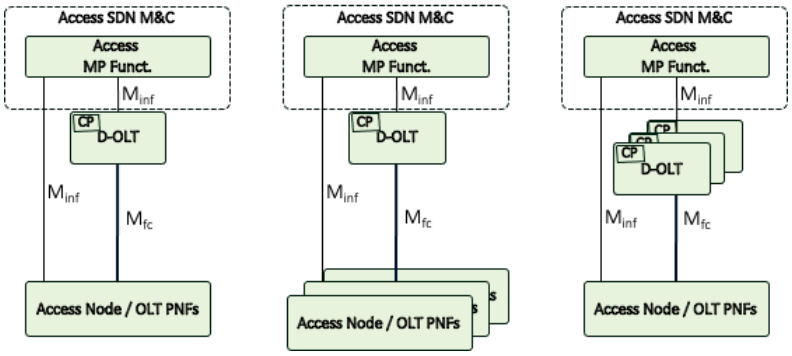

Figure 3 – Flexible deployment options for D-OLT

Figure 3 illustrates three flexible deployment options:

- **Direct relationship between D-OLT and Access Node / OLT**: A D-OLT only manages one Access Node / OLT. This approach replicates the existing solutions already deployed in operators' networks. This allows an easy migration from legacy architecture to the disaggregated one.
- **A single D-OLT manages multiple Access Nodes / OLTs**: This solution takes advantage of the disaggregation by increasing the efficiency of the resources to be utilized. This is applicable, for example, when certain functions to be virtualized can be centralized.
- **Multiple D-OLTs manage the same Access Node / OLT**: This is applicable in case of network sharing or slicing when multiple virtualized functions, one per slice, refer to same physical entity.

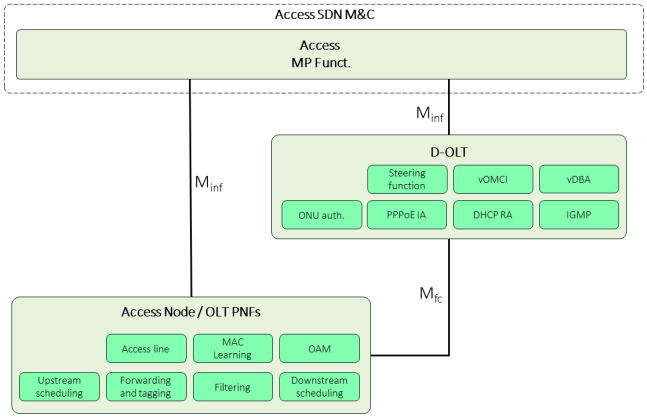

Figure 4 – Access Node / OLT and D-OLT Functional Architectures

Access Node / OLT and D-OLT functional architectures and related interfaces are described in Figure 4.

Access Node / OLT shall support the following functions:

- Functions related to access lines
- L2 functions
- All the related functions that are not virtualized

On the other end, D-OLT represents a logical repository for all the functions to be virtualized. It can be located in local servers close to Access Node / OLT or centrally in cloud. It can be also split between the two locations, for example:

- locally for all the functions that are latency sensitive
- centrally for all the functions which performances are not impacted by latency

4 The Need for Access Node Hardware Disaggregation 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 Access Node Hardware Disaggregation initiative defines the architecture, requirements and interfaces required for implementation of Access Node Hardware Disaggregation in a CloudCO compliant manner, essential for interoperability, deployment agility, and reduction in total cost of ownership. The latest release of the CloudCO Reference Framework can be found here.

5 Terminology

5.1 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-384	*Cloud Central Office Reference Architecture Framework*	Broadband Forum	2018
[2]	TR-408	*Cloud CO Migration and Coexistence*	Broadband Forum	2020
[3]	WT-477	*Disaggregated Access Node*	Broadband Forum	TBD
[4]	TR-411	*Definition of interfaces between CloudCO Functional Modules*	Broadband Forum	2021
[5]	TR-413	*SDN Management and Control Interfaces for CloudCO Network Functions*	Broadband Forum	2018

5.2 Definitions

The following terminology is used throughout this document.

CloudCO	Central Office (CO) Domain that is (1) leveraging SDN and NFV techniques, (2) running on a cloud-like infrastructure deployed at Central Offices and (3) that is accessed through a Northbound API, allowing Operators, or 3rd parties, to consume its functionality, while hiding how the functionality is achieved from the API consumer.
Disaggregated OLT	D-OLT represents a logical repository for all the functions to be virtualized. It can be located in local servers close to pOLT or centrally in cloud. It can be also split among multiple locations (local and central).

5.3 Abbreviations

This document uses the following abbreviations:

BBF	Broadband Forum
CapEx	Capital Expense
CO	Central Office
CP	Control Plane

DHCP	Dynamic Host Configuration Protocol
D-OLT	Disaggregated OLT
DSL	Digital Subscriber Line
G-PON	Gigabit Passive Optical Network
IP	Internet Protocol
MD	Marketing Draft
MR	Marketing Report
OLT	Optical Line Termination
OpEx	Operating Expense
PPPoE	Point to Point Protocol over Ethernet
SDN M&C	SDN Management and Control
SDN/NFV	Software Defined Network and Network Functions Virtualization
TR	Technical Report
UP	User Plane
WT	Working Text
XGS-PON	10 Gigabit Symmetrical Passive Optical Network

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