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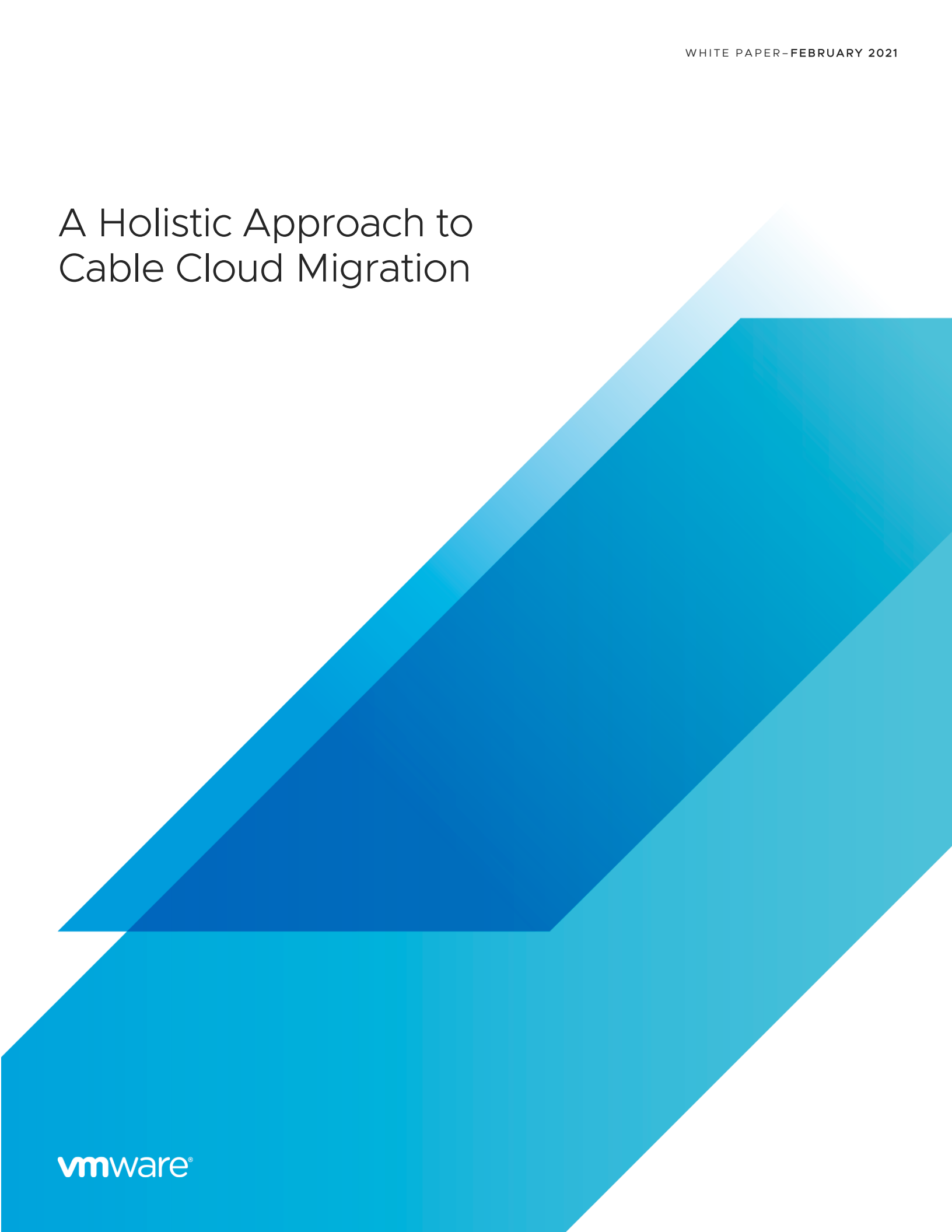
A Holistic Approach to Cable Cloud Migration



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Introduction

Cable multiple system operators (MSOs) across the globe have come to recognize that cloud technology is critical to enabling fast and cost-effective advances that will allow them to keep pace with market demand and meet competitive challenges.

But operators need to find a practical way forward that allows them to operationalize virtualization in whatever ways work best for them without fear of unforeseen consequences now or later. That means they must be able to incrementally virtualize network functions as priorities dictate with absolute assurance, they will be able to continually expand virtualization to other functions relevant to any category of use cases while maintaining quality-assured harmony with relevant legacy network functions.

This can be accomplished effectively through holistic integration of virtualized network functions under common cloud-based virtualization platform that allows operators to eliminate legacy silos as they proceed ever deeper into cloud migration. And they need to be able to do this with complete freedom to adjust cloud strategies and vendor choices as they go.

These goals can now be met.

As evidenced in network cloud transformations underway worldwide, operators can employ any mix of virtualization technologies in tandem with traditional hardware elements under the control of a common and consistent automated operations platform across the datacenters, access networks and the clouds. This can be done in unitary or multi-cloud environments with any set of functions relevant to any combination of applications in any deployment configuration.

These holistic vendor-agnostic approach rely on the converged virtualization platform developed by VMware, the pioneer and leading supplier of the technology that has been driving cloud transformation across multiple industries worldwide for the past 20 years. VMware's cable cloud solutions optimize these capabilities for the cable industry with full support from expert teams dedicated to operators' needs.

Most MSOs supported by VMware are focused on employing containerized approaches to virtualization, but some began cloud migration earlier with utilization of the virtual machine (VM) technology. This is not an issue for these operators, because any combination of containerized and VM functions can be managed holistically through the seamless orchestration enabled by VMware's cable cloud platform.

The discussion that follows begins with a look at why cloud migration has moved to the cable industry's front burner, followed by an exploration of the issues that have impeded progress in that direction.

Next, we enumerate possible paths to virtualization that must be accommodated by a cable-optimized cloud platform. The discussion concludes with an overview of the requirements that enable this level of flexibility under control of virtualization platform that is agnostic to vendor solutions, modes of virtualization and course changes over the period of migration.

The Inevitability and Challenges of Cable Cloud Migration

CapEx & OpEx Benefits

Over the past couple of years, MSOs and their suppliers have shed their doubts about the reliability of virtualized cloud solutions as a replacement to traditional hardware-based approaches. As a result, the inevitability of cloud migration is now an accepted premise in network planning across the industry.

Operators know they can get the robust performance they require from virtualized headends, hubs, new edge facilities, nodes and customer premises equipment (CPE) utilizing software solutions that scale up and down on commercial off-the-shelf (COTS) processors. This frees them from the capacity constraints and costs of upgrading and replacing purpose-built hardware, and it enables shared usage and cost-efficient scaling of COTS resources for multiple applications on an as-needed basis.

All of these attributes add up to significant CapEx savings.

Equally, if not more important, virtualization enables the innovation agility and service acceleration essential to reducing OpEx. By eliminating the time-consuming impediments posed by executing operations in separate service and access network silos, operators can maintain a competitive edge in a market evolving at Internet speed.

By reducing silos, cable operators can efficiently and quickly fulfill demand for any type of service or application on any type of access network, be it HFC, fiber or wireless, cable operators open new opportunities to drive new revenue, increase return on investment (ROI) and improve Quality of Experience (QoE).

The Search for a Viable Way Forward

But, despite all these benefits, it has been hard for cable operators to forge a cloud migration strategy when, by necessity, applications of virtualization technology must be centered on the immediate priorities of network evolution. While vendor support for virtualized versions of various components of network infrastructure elements abound, operators have come to recognize these solutions can't be implemented without taking into account the expanding cloud transformation environment that they know they'll be implementing over time.

The question is, is there a way forward on the path to cloud transformation that is future-ready that MSOs will have freedom to operationalize whatever choices work best for them without fear of unforeseen consequences now or later? It's one thing to be able to run trials of various instantiations of virtualization. It's quite another to be able to operationalize those instances without costly service disruptions, reliance on expert integration services, development of new skills and processes, and a need for more experimentation.

Cable decision makers' considerations about whether and how to apply cloud technology invariably are laser focused on instances where cost, operational and service velocity benefits can be attained in conjunction with their most pressing priorities. First and foremost, they evaluate whether and how the virtualized elements will seamlessly interoperate with all the legacy components essential to execution of the targeted functions.

Moreover, even when such interoperability is achieved in the immediate instance, they need to be certain they'll be free to make best-of-breed choices as they expand the reach of virtualization over time. The last thing they want is to be boxed into making future choices between stranding capital or pursuing less-than-optimal solutions.

Such concerns have been a major impediment to cloud migration in the cable industry. One school of thought suggests the best way forward is to hold back on virtualization until the industry works out a comprehensive roadmap describing how all the pieces should fit together in a fully virtualized operations environment. Others believe the need to realize the benefits with immediate initiatives is so great, it's worth the risk to plunge ahead without a fully articulated vision of where they're going.

A third way forward is to define the requirements that have to be met by an operational framework that would allow operators to apply virtualization in sequence with ongoing priorities, knowing those choices will stand up over time even if there's no roadmap to a final outcome. To understand what this would entail, it's useful to consider the many approaches to virtualization under consideration by MSOs that must be accommodated by such a platform.

Cable Migration Options that Must be Open to Operators

Virtualization with HFC Migration

One major area of activity where virtualization has entered the discussion involves Hybrid Fiber Coax (HFC) migration, driven by demand for more bandwidth, better signal quality and reductions in facilities space and power consumption. DOCSIS 3.1, by virtue of the shift away from traditional Quadrature amplitude modulation (QAM) channel architecture in conjunction with the spectral efficiencies attained with Orthogonal Frequency Division Multiplexing (OFDM) and other advances, works in parallel with ongoing expansion and operational flexibility through implementation of Distributed Access Architecture (DAA).

DAA, which can also be implemented with DOCSIS 3.0 though seldom is, represents a migration step toward creating a foundation for long-term network evolution, starting with deployment of digital optical links along with Remote PHY Devices (RPDs) to enable execution of digital-to-RF conversion at the node. Digital delivery of optical signals significantly expands link power budgets to enable greater transmission distances at much lower maintenance costs compared to analog transmission. With higher wavelength density enabled by digital transmissions, operators can expand the number of nodes served at multi-gigabit data rates while enabling more efficient use of available fiber in node migration, including eventual moves to Fiber Deep, where the number of amplifiers between the node and users served by coaxial plant is reduced to 1 or 0.

The cost and versatility in DAA migration heavily depends on the versatility of Converged Cable Access Platform (CCAP) equipment, which is rapidly replacing the traditional CMTS platform. While DAA does not require virtualization of the CCAP, most engineers want to avoid tying DAA modules to the slow development cycles, space inefficiencies and heavy power usage of traditional hardware.

At the same time, although CCAP virtualization is often associated with the move to DAA, many operators see a need to pursue CCAP virtualization independently of DAA migration. As they replace their Cable Modem Termination System (CMTS) with the new platform, they want to adopt the virtual CCAP (vCCAP) approach where use of general-purpose servers supporting DOCSIS software modules

afford them the flexibility to quickly expand capacity across additional servers and to reposition the PHY and MAC modules when they're ready to implement DAA.

Of course, CCAP virtualization is essential for enabling the next phase of DAA migration, which involves separation of MAC as well as PHY processing from the core CCAP controller. As defined in recently released CableLabs® specifications, a flexible approach to positioning MAC processes, known as Flexible MAC Architecture (FMA), enables remote positioning of all or portions of the MAC layer at intermediate points between the core and nodes as well as at the nodes, depending on what works best for each MSO.

Virtualizing New Wireless Infrastructure & Multi-Network Operations

A logical starting point in cloud migration for many cable operators involves building support for new wireless infrastructures, usually in conjunction with enabling their own 5G services and/or creating opportunities to offer front- and mid-haul backhaul services to mobile operators. Operators can employ cloud technology with remotely positioned datacenter components in headends, hubs and even HFC nodes to meet their goals.

Notably, where 5G is concerned, major DOCSIS technology advancements aimed at satisfying transport capacity, latency and distributed architecture requirements allow MSOs to optimize 5G RAN (Radio Access Network) architecture for whichever business models make sense for them. They can take advantage of the expanded bandwidth capabilities of DOCSIS 3.1 in conjunction with DAA to create a thin layer of spectrum supporting RAN (radio access network) signaling. They can position cloud-based RANs in edge sites or locate some of the distributed datacenter functions at the node level.

But as operators take advantage of this virtualization-enabled networking versatility, they want to be sure they can leverage the cloud technology used to instantiate 5G infrastructure to support whatever their next steps might be as they extend virtualization into other areas. And the same holds for operators who implement virtualization in new passive optical networking (PON) environments.

Indeed, some operators are focusing early applications of cloud technology on operational consolidation of all their access networks regardless of whether they are using virtualization with the physical infrastructures. Currently, the service and applications layers associated with managing consumer and commercial services over the PON and wireless access modes coming into play with HFC are run as separate silos. Abstracting and virtualizing processes common to provisioning and managing services and applications across all these networks will enable operators to scale different physical facilities as they see fit.

Equally important, centralized management and multi-layer automation and operations across multiple networks expedites operators' ability to replace one mode of access with another. This will likely have to be done at mass scale, given the role ubiquitous wireless connectivity is destined to play in the fast-changing broadband services marketplace. Cable operators will be able to scale services and operations across multiple facilities with assurance that wireless coverage can be broken into ever smaller areas as usage densities increase and wireless becomes the primary means of connectivity for all customers wherever they are.

Virtualizing the Video Headend

In some cases, rather than taking a data-first approach to virtualization, operators are using cloud technology in their headends to streamline video operations. This doesn't necessarily mean they are replacing hardware devoted to encoding, security and other traditional processes.

Rather, these uses of virtualization facilitate management of bandwidth used for video through the video control plane of the CCAP with no disruption to legacy TV channel distribution. Used in conjunction with Remote PHY instantiations of DAA, this allows direct spectral placement of RF video channels in ways that free up more RF spectrum for downstream and upstream data communications. This set-up can also be employed with switched digital video (SDV) technology to reduce video bandwidth. And it plays in tandem with the evolution to IP video, facilitating IP processing at the core while using traditional transport to reach legacy STBs.

Virtualization at the Network Edge

CCAP virtualization, especially in conjunction with positioning of the MAC layer in DAA, brings edge facilities into play as another key area of cloud transformation. In fact, the benefits derived from utilization of commodity appliances at the edge are a major driver to virtualization in many cases.

Where MAC positioning is concerned, operators may not want to place MAC processing in every node, but they do want to have that layer in close enough proximity to end users to enable ultra-low latency. CableLabs has developed Low Latency DOCSIS specifications aimed at getting the one-way latency of signals used in emerging applications like fast-action gaming, Virtual Reality, 5G and

driverless vehicles down to 1-2ms., which, based on the light speed limit, requires positioning of the MAC layer within 300km. of the end points.

Beyond support for vCCAP instantiations, a primary role for these multi-purpose edge datacenters is to expand on the traditional CDN concept. In fact, given the demand for TV-caliber performance by the growing number of over-the-top (OTT) suppliers, some cable operators see an opportunity to help fund their own transitions to next-generation operations by providing content delivery network (CDN) services to other entities as well.

Software running on these virtualized edge datacenter facilities vastly expands on the capabilities of traditional CDNs, performing processing of content in support of virtually any live or on-demand multiscreen service model. Dynamic, targeted ad insertion, personalization of user experience, adherence to local blackout policies, support for time shifting and feature enhancements of every description can all be performed at the edge, leaving just a short hop for streaming at quality levels suited to display on big screens as well as handheld devices

Typically, the currently targeted facilities include local hubs or headends, which some MSOs are rapidly converting into mini datacenters. In addition, in instances where they don't have local facilities or they're not adequate to supporting the power consumption and heat generation of a datacenter, operators are installing facilities in converted warehouses and other centrally located buildings.

Virtualization of Residential CPE

Closely paralleling the move to virtualization of processes tied to IP distribution of premium video is the role virtualization is playing in efforts to reduce the costs and processing requirements of set-tops and residential gateways (RSGs), including whole-home media and Wi-Fi gateways. On the set-top/media gateway side the emergence of cloud-based middleware systems that support shifting DVR-related functions, composition of the EPG, personalized navigation features and other traditional whole-home media gateway functions to the cloud has now made virtualization of these types of RSGs a top priority for some operators.

Moreover, through cloud virtualization of RSG processes, including visibility into each user's profile, operators lower the costs and greatly enhance management control over distribution of video service and personalized applications to all devices in the home. And through cloud virtualization, costs of configuring services in the home are greatly reduced as well. Rather than sending technicians, operators can send subscribers packaged software that will allow RSGs to configure themselves on the network and to extend configuration to all other devices in accord with the policies appropriate to each one.

While much of the virtualized processing along with the physical storage associated with virtualized CPE will be centralized in the new cloud headend, full realization of the time-shifting capabilities of IP technology will require application of virtualized storage management to edge caching system as well. In fact, the primary factor determining the location and duration of storage will be the policies that determine "start-over," "catch-up" and network DVR uses of storage facilities. Licensing as well as time factors underlying these policies will be executed in closely coordinated application of virtualized processes to commodity hardware at the headend and the edges.

Where Wi-Fi gateways are concerned operators are moving beyond Wi-Fi enabled cable modems to deploy Wi-Fi RGWs as the new linchpins to ubiquitous connectivity for all services throughout the premises. These services include digital voice as provided through eMTAs (cable modems with embedded multimedia terminal adapters) as well as HDTV, multiscreen video and broadband services.

Cloud Initiatives Supporting Commercial Services

Paralleling the consumer service and CPE virtualization priorities, MSOs are finding that virtualization is fast becoming an intrinsic component of commercial services as well. In fact, it's now evident that in order to compete effectively in the fast-changing SMB market cable operators will need to pursue virtualization fairly aggressively to keep pace with market developments.

The service velocity, personalization, cost, scale and other benefits of virtualization described for the consumer market apply equally to facilitating operators' ability to serve businesses. In addition, the popularity of the cloud-based software-as-a-service (SaaS) model has outgrown the traditional network services model, where manual change control processes are becoming a bottleneck to fulfilling changing needs of business customers.

Virtualization has an especially important role to play as MSOs capitalize on opportunities to offer value-added cloud-hosted services through software-defined wide area network (SD-WAN) connectivity, which, as the name implies, is an innately virtualized service that utilizes software to make secure private network operations available to businesses of all sizes. Workers connected to SD-WANs,

wherever they are, can access distributed workflows for virtually any task utilizing in-house tools and processes alongside cloud-based applications hosted by cloud service providers.

Two other key areas of virtualization, CPE and multi-network operation consolidation, which were mentioned earlier in conjunction with consumer services, are as important, if not more so, to business services. A top priority for commercial service providers is to lower business CPE costs by using the cloud to support inexpensive layer 2 Wi-Fi gateways as the points of connecting devices office-wide. And with PON connectivity now widely used in extending network reach to larger businesses, multi-tenant office building and industrial parks, operators have a great incentive to consolidate multi-network operations by virtualizing provisioning and management of services and applications.

Virtualizing Internet of Things Services

Cable operators seeking to capitalize on IoT-related service opportunities know they will have to support a massively scalable environment for accommodating all the cloud-based processing essential to managing individual devices and orchestrating coordinated usage of generic devices like sensors across multiple applications. By nature, these are devices designed to minimize battery power consumption in the interest of maximizing longevity, which means they will rely heavily on cloud-based processing to drive their responses to specific application requirements.

Virtualization of IoT devices will be essential with cloud instantiations hosted at multiple cable network edge locations. This is the case not only because of the sheer volume of devices that will need to be managed in any given local service area but also because operators will have to keep latency levels so low that devices relying on cloud processing will be able to react to conditions as if the processing were hosted on the devices.

Operators may also want to mount IoT services for individual customers that coordinate uses of sensors and other devices across multiple locations. Cable's wireless footprint will be a major factor in operators' ability to compete for this business, which means management of the virtualized IoT domain will have to be tightly coordinated across outdoor and premises access points at widely dispersed locations.

Essential Features of a Future-Ready Cable Cloud Platform

Complete Flexibility in All Directions

With all these paths to virtualization in play, MSOs must be able to take whatever course they choose with absolute certainty that the cloud orchestration technology they employ now will carry them through ongoing cloud migration. And they must be free to pursue any path with assurance that the virtualized functions will interoperate seamlessly with functions that remain under control of legacy hardware.

Operators must also have the flexibility to execute virtualization and operation of the control and data planes independently, as envisioned in the network function virtualization (NFV) specifications developed by the European Telecommunications Standards Institute's (ETSI's) Industry Specifications Group for NFV (NFV ISG). This includes the ability to implement virtualization of these planes on separate timelines in any order in each area of cloud transformation, which can be done with convergence of virtualization on a common substrate.

In any given instant an operator may want to focus on virtualization of the control plane leaving the data plane under control of legacy components but will want to be certain that the platform will support eventual virtualization of the data planes, without disruption to the existing cloud instantiation. The reverse holds as well. For example, an operator may want to focus on virtualization of edge components while postponing to a later date virtualization of the relevant core control plane processes.

Full realization of the power of cloud transformation to accommodate all the benefits of virtualization will also require a framework that allows MSOs to utilize and control cloud native containerized and hypervisor based VM instantiations in any combination for any set of functions. This means operators must be able to position virtualized network functions (VNFs) and containerized network functions (CNFs) to work in tandem wherever they choose whether in the core or in distributed configurations at headends, hubs, nodes, RAN stations, premises or anywhere else network intelligence is in play. And operators must be able to seamlessly incorporate any previously operationalized vendor cloud solutions into the holistic cloud management environment, regardless of which type of virtualization technology is in use.

The allocation and management of VNFs and CNFs across all locations must be executed holistically with as much speed and efficiency as if they were all running in a single datacenter location. And operators must be able to tap public cloud resources for seamless extensions of private cloud instantiations regardless of which mode of virtualization is in use.

Interoperability with Legacy OS Systems

These goals can only be met with the support of a comprehensive cloud orchestration platform that has been designed specifically to unify management of each segment of cable operations in a hybrid cloud/legacy hardware environment. In so doing, the platform, utilizing industry standard interfaces, must be able to work with all legacy OSs without disruption to how each network and service team goes about managing their workflows.

Because cloud transformation potentially touches every aspect of the business, this holistic cloud/legacy management imperative applies to:

- All facets of consumer and commercial services operations, from service and application development to asset management, processing, security, provisioning, delivery, quality control, customer service, personalization and modes of monetization.
- All aspects of end-to-end network management across all access modes, from HFC to PON, other FTTP technologies, Wi-Fi and mobile.
- All B2C and B2B front- and back-office operations, from billing and settlements to sales and marketing, customer service and HR.

Elimination of Impediments to Rapid Deployment and Performance Assurance

Cost and hassles of deploying cloud platforms should no longer be impediments to virtualization. That means the cloud orchestration platform must be ready to deploy without requiring manual integrations of the operational layers once the platform is instantiated on servers. And complications that have impeded operationalization of microservices in a Kubernetes cluster must be eliminated.

The cloud platform must provide a level of support for fault and performance assurance and ongoing configuration and policy management that can only be accomplished with the application of advanced analytics aided by machine-learning technology. It must be able to deliver superior QoS and QoE with increased visibility over all aspects of multi-network operations.

Much of the quality control can be executed through self-healing mechanisms that utilize automated approaches to identify and address root causes of problems, thereby reducing truck rolls and the need for on-site technicians. At the same time, performance data aggregation with machine learning-based analytics streamlines operators' ability to tune into operational results and make whatever adjustments in service routing, allocations of COTS resources and utilizations of wireless access point functions that are needed to proactively prevent problems from impacting user experiences or, in cases where the impacts are felt, quickly implement remedies to minimize disruption.

Conclusion

In an era marked by a global industrial shift to reliance on cloud technology, MSOs have every reason to be confident an outpouring of cloud-based vendor solutions touching on every facet of network operation will give them the versatility to compete aggressively in any service sector they choose, whether via fixed or wireless connectivity.

With a framework as described here, cable operators can forge ahead with implementation of virtualization incrementally wherever and whenever it suits their specific needs. They'll be able to continually break down silos while leveraging legacy components in a holistic cloud operations environment that can be expanded seamlessly across multiple clouds and all points of their infrastructure without restrictions on their ability to select the most optimal solutions every step of the way.

VMware's Cable Cloud Solutions

VMware's cable cloud solutions meet these requirements with a standards-based, vendor- and application-agnostic platform buttressed by automated support for every facet of cloud technology instantiations and converged cloud/legacy operations.

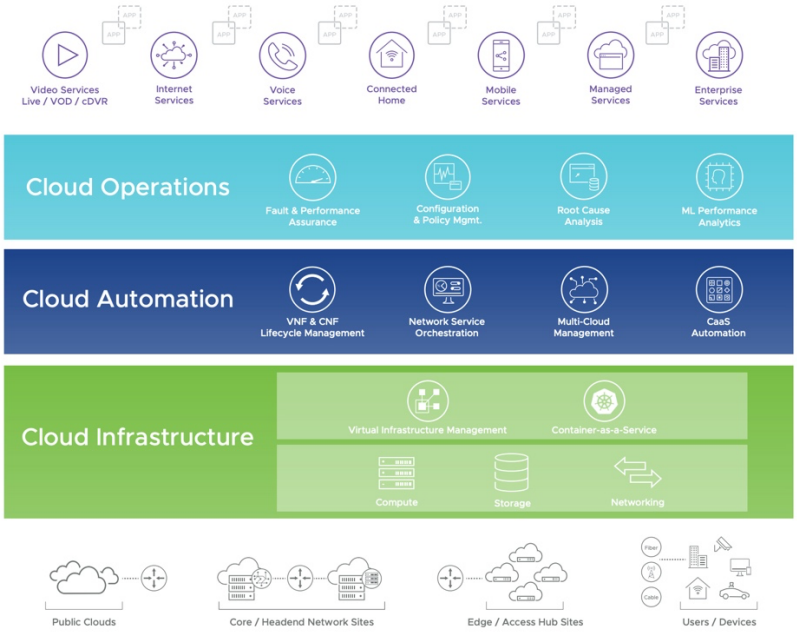

FIGURE 1: VMware's Cable Cloud Solution.

VMware's cable cloud solutions enable cable operators to transform the network and unify operations across any network in any cloud for any application running on any device. It expedites innovation cycles, reduces operational complexities, and generates substantial TCO savings over other approaches, further accelerating the cable transformation journey to next generation clouds.

With VMware's cable cloud solutions, cable operators accelerate their network transformation and services deployment with a consistent cloud platform that extends throughout the infrastructure, automation and operations, across the network from the core to the edge, and in multi-cloud environments. Using a cloud-first approach, VMware's cable cloud solutions deliver a new level of operational agility for virtual, cloud-native, and edge network functions. VMware's cable cloud solutions are powered by a field-proven VMware Telco Cloud Infrastructure™, coupled with VMware Telco Cloud Automation™, that is further enhanced with VMware Telco Cloud Operations™.

To learn more about VMware's cable cloud solutions, please visit *www.vmware.com/cablecloud* and download the solution brief or contact your VMware representative.

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