Virtual Business CPE

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Abstract

Evolution of network-based services that has come to be known as cloud computing gave rise to Software Defined Networking (SDN) and Network Function Virtualization (NFV). These technologies are migrating from data centers to data communications networks, resulting an a paradigm shift in structures and management of networks.

SDN and NFV allow for more flexible and agile deployment of networks and network services, and can facilitate innovation of services. CableLabs is applying Lean Startup methods to develop and validate data models and APIs exposing open source network controller functions for business services applications. The APIs enable use of OpenDaylight open source controller platform to configure virtual switches as virtual business CPEs.

VIRTUALIZATION OVERVIEW

Cloud Computing and Virtualization Technologies

The term 'cloud computing', and the use of the term 'cloud' to refer to a remote server network or the Internet in particular, has been in use less than 10 years but its use has become widespread. Useage of the term cloud computing varies but it typically refers to the provision of services from servers in one or more remote data centers accessed via the Internet or private wide-area network instead of from a local server or network.

Development of cloud computing in the mid-2000s by companies such as Google, Amazon, and Microsoft is important to the computing and networking industries for several reasons. One is cloud computing enabled service providers to resolve or prevent problems such as space limitation, electric power limitation and overheating in local or on-premise facilities caused by continually increasing the number of servers needed to provide services to a growing customer base. Moving demand to servers in remote data centers alleviated demand on the local infrastructure while continuing to provide services, such as e-mail service and file storage service, to customers.

Another important outcome of development and optimization of cloud computing was application and evolution of software defined networking (SDN). Software defined networking as it's currently known derived from many years of research, specification, and implementation to make network behavior software programmable.

Key characteristics of SDN are separation of the data plane and control plane, and centralization of control plane functions under a single software controller via a well-defined application programming interface (API). The controller communicates to network elements via the API to establish data paths and configure network functions and rules such as packet forwarding and dropping.

SDN was not developed specifically for cloud computing applications but it lends itself well to the environment where programmability of network elements provides flexibility and ease of configuration and management. This is especially useful for dynamic environments like data centers, where demand for service fluctuates over time.

Rapid growth of network traffic driven in large part by the increase in the number of mobile devices sending and receiving data creates challenges for managing traffic and network resources. SDN provides a means of improving manageability of a network. By providing a centralized point of control in the network, SDN allows a more global view of the resources and traffic. Programmability of control functions acting on network elements through APIs help enable the automation of network engineering and resource allocation. Automation of network engineering is a tool that can help networks scale with increasing traffic demand.

Virtualization in data centers or in a network can be done for hardware or software components of the system. Hardware virtualization refers to initiating virtual machines or self-contained instances of an operating system and software applications on a hardware platform emulating an independent compute, storage or network hardware device.

Virtual machines allow the rapid creation of compute, store or network resources when the workload demands it and the rapid deletion of the resources when they are no longer needed. VMs also allow more efficient use of servers and other hardware devices by adding functions to existing servers without having to find space, power and heat control for another physical server. VMs also enable compute resources to be rapidly cloned in any server location.

Network Function Virtualization (NFV) is another technology enabled by, and potentially leveraged by, cloud computing. NFV involves implementing network functions such as routing, switching, tunneling, packet tagging, Service Level Agreement monitoring, and load balancing to name a few as software functions that can be run independently or as a group on industry standard servers.

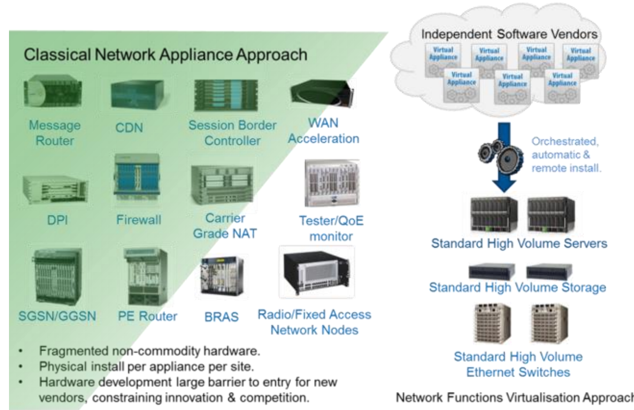

Figure 1 Vision for Network Functions Virtualisation (ETSI NFV ISG – NFV White Paper)

Separating functions provided by networking equipment into modules that can be instantiated when and where they are needed, and deployed on commodity storage, computing or data forwarding platforms enables a high degree of flexibility in configuring a network and allows changes to be made quickly.

Other benefits of virtualizing network functions include increased rate of innovation, opportunity for more centralized control and monitoring, and reduced capital expense.

SDN and NFV allow data centers to evolve away from collections of purpose-built hardware platforms confined to a limited number of racks in a particular facility to virtualization of compute, store, and network functions that can be cloned, chained and distributed into as many commodity hardware platforms as needed. This creates a new paradigm for flexibility in service deployment, ease of management and opportunity for rapid development of services.

SDN Controllers

Cloud computing and networking technologies developed for use in data centers for IT industry are making a transition to telecommunications. Emergence of access technologies such as the cable industry's DOCSIS 3.1 data over cable specification, Ethernet Passive Optical Network (EPON), and EPON Protocol over Coax (EPoC) brings network speeds to market that make use of SDN and NFV for data communications across service provider networks feasible.

As SDN and NFV technologies are rapidly evolving, so too are open source SDN controller projects. An SDN controller is a software framework that abstracts and exposes command and control of real or virtual network elements to applications through a common set of application programming interfaces (APIs). The controller is the central point of control for the network when network control has been separated from the data plane.

Commercial SDN controllers are available from several technology providers such as Big Switch, Plexxi, Brocade, Hewlett-Packard, Juniper and Cisco. Commercial controllers offer support from the manufacturer and are designed to integrate well with the manufacturer's networking hardware and software, as well as with open source components and controllers.

Open source controllers, like other open source software, are generally developed in a collaborative environment and software developers share code changes with other developers. Code is made available to the developer community for download often under an open source license, and members of the open source developer community can modify the source code and publish the changes back to the community as a fork in the code. Open source development enables rapid development and the opportunity for innovation by drawing on the experience and skills of a relatively large and diverse pool of developer resources. Open source development, including new features, feature enhancements, and bug fixes can happen at a pace dictated only by the availability of developers to work on the code.

Open source controllers include Beacon, Floodlight, POX, Open Contrail, and OpenDaylight. Floodlight and OpenDaylight are both written in Java, both are supported by large communities of developers and both have a large number of functions that can be combined to create a controller environment optimized for a particular network. Most open source controllers support OpenFlow, an open standard protocol for controlling data flow in a network. Unlike the other open source controller options, OpenDaylight provides a Service Abstraction Layer (SAL) that manages plug-in modules for several protocols used to communicate with and control network devices, including Netconf, OVSDB, SNMP, and others in addition to OpenFlow.

Orchestration

As network configurations become complex and span multiple networks and in some cases multiple service providers, a system monitor is needed to maintain information about services and elements and to control and manage systems and groups of systems. In cloud computing this function is performed by the orchestrator.

The orchestration layer abstracts network controller functions from the applications layer. In turn the controller abstracts network elements and connections from the orchestration layer. These relationships are shown in Figure 2.

VIRTUAL BUSINESS CPE PROJECT

Accelerating SDN and NFV Readiness Using Lean Methodology

Established network solutions vendors as well as startups including SDN controller providers are making data center and networking SDN and NFV solutions available now and adoption has begun worldwide. However the rate of deployment is limited by logistics of the change to a new architecture and lack of understanding about SDN and

NFV and their implications. Technology media company TechTarget recently reported results of a survey of IT companies worldwide about their priorities for 2015. Of responding companies 15% reported plans to implement SDN and 27% plan to implement network virtualization. Lack of understanding of SDN and NFV technology was cited as a reason for delaying SDN and NFV deployments.

CableLabs with support from its member cable companies initated a project in 2014 that uses a Lean Startup approach to quickly learn how to apply SDN and NFV to data networking using business services as a set of use cases to focus efforts. Business service providers recognize that SDN and NFV have potential to improve efficiency of their operations and facilitate product innovation and development of new services for their business customers. The project is focused on SDN and NFV on open source implementations and selected OpenDaylight as the open source controller for a reference platform.

The Lean Startup method defined by entrepreneur Eric Ries optimizes capital and human creativity to drive creation of successful output by leveraging lean manufacturing techniques. Lean Startup methodology includes rapid scientific experimentation, early feedback from stakeholders, focus on essential features and rapid adaptation to feedback and changing conditions.

The business services sector of a service provider's business includes a wide range of services including Ethernet services, cellular backhaul, virtual private networks (layer 2 and layer 3), cloud services, security services and more. To make progress on developing SDN and NFV solutions for business services using 'rapid scientific experimentation' a method is proposed to develop a prioritized list of business services use cases then focus on developing standard data models and application programming interfaces (APIs) for the network services for each use case, leveraging available open source controller platforms. The APIs expose functions of the OpenDaylight controller required to implement network services, using virtual or actual network resources for each use case.

Network services APIs can then be shared with the open source community to be standardized for use by business services application vendor companies. In this way the open standard APIs will help enable the vendor community develop business services SDN applications and virtual network functions for service providers, leveraging the open source controller.

By focusing on each use case as a "thin slice" of the communications stack and developing and validating the data model and API for each slice, the challenge is subdivided into manageable segments. By submitting the APIs and data models to the open source community optimizes the APIs for the open source controller platform(s) and makes the APIs available to application developers.

Figure 2 illustrates the thin slice concept. Here the use case shown is MEF Services, which refers to Service Definitions specified by Metro Ethernet Forum such as Ethernet Private Line service. The open source controller is shown as OpenDaylight.

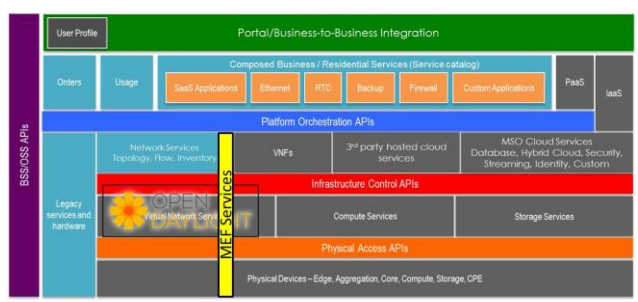

Figure 2 CableLabs CableCloud Architecture with Thin Slice

The network services APIs, working through the open source controller, assist business services applications with configuring network resources such as virtual switches for necessary connectivity and service level agreement (SLA) enforcement such as burst rate control, throughput limiting, and MTU size enforcement. Much of this configuration can be considered SDN functionality.

Where virtual switch configuration is not sufficient to satisfy business services objectives additional capabilities can be added by appropriate virtual network functions (VNF). For example, many SLAs require enforcement and monitoring of performance parameters such as throughput rate, delay and jitter. A virtual network function may reside in the cloud, in a network element, or divided between the cloud and network elements. Figure 3 illustrates this concept with Fault Management and Performance Management VNFs in the network element as well as FM and PM VNFs in the cloud.

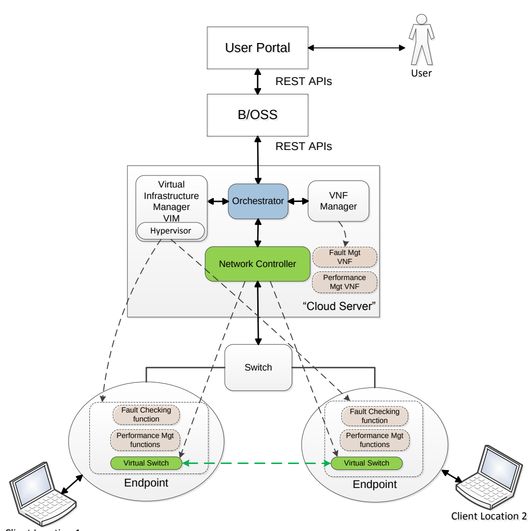

Figure 3 Ethernet Private Line Service Using Performance Management and Fault Management VNFs

Business services deployments use a Network Interface Device (NID) at the customer's premises to terminate the service provider's network and interface the service provider's network to the client's network. Figure 3 shows a generic 'endpoint' network element that represents the role of a NID. The NID performs several functions supporting the delivery of business services including bandwidth management, quality of service, packet tagging, and SLA monitoring such as loopback testing and other performance management functions and detection of faults in the network.

Like other elements of a network, a NID can be implemented using SDN and NFV to realize benefits previously mentioned. Indeed, MEF specifies Virtual NID (vNID) object definitions, and technology providers have begun announcing Virtual NIDs or Virtual Business CPEs but they are as yet immature and not yet fully leveraging the flexibility and automation potential of SDN and NFV.

Open source controller platforms are still evolving. Some Virtual Business CPE or vNID vendors are starting to use some aspects of open source controllers in their products but the potential of the open source controller platform is not yet being realized.

As open standard APIs for business services are made available and optimized for open source platforms and technology suppliers leverage them to develop applications and virtual network functions for business services, the virtual business CPE will also become a key part of the virtualization of business services.

CableLabs' goal is to help establish the cable industry as a leader in open source NFV innovation, specification, and integration. CableLabs has established several projects within its CableCloud initiative to move the state of NFV technology forward. The Virtualized Business CPE project is following the 'thin slice' approach and developed data models and APIs for provisioning of Ethernet Private Line service using OpenDaylight. The project developed a development and demonstration platform illustrated in Figure 3, using Raspberry Pi small form factor computing platforms running virtual switches to emulate the NID. Using a simple UI to initiate the process, the APIs call OpenDaylight to configure the virtual switches in the Raspberry Pis to establish a connection between them. The platform validates the APIs and proves the concept of creating virtual business CPEs using APIs and OpenDaylight.

The initial use case or 'thin slice' was Ethernet Private Line service. The project will continue by expanding the data models and APIs to include support for additional business services.

CableLabs believes in participating in open source projects to enable and facilitate vendors developing business services solutions for service providers such as the cable operators. This includes submitting work to open source projects for continued development and eventual release to business services application developers.

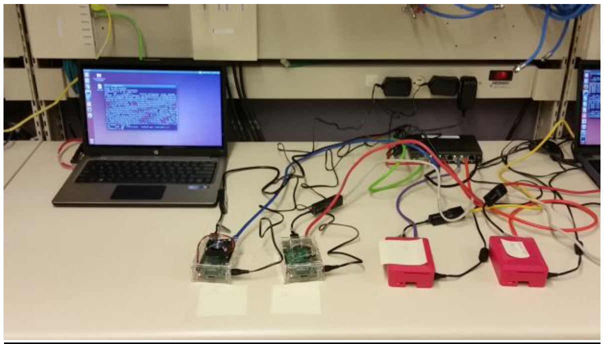

Figure 4 CableLabs Virtual Business CPE Development and Demonstration Platform

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