The New Networking Stack

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Leverage Technology & Talent for Success

Introduction

This is the second in a series of three white papers that examine the changing IT environment in general, and the changing networking environment in particular. One of the primary factors that are driving rapid change is the need for IT organizations to be able to support the quickening pace of business. According to Professor Richard Foster[1] from Yale University, "The average lifespan of a company listed in the S&P 500 index of leading US companies has decreased by more than 50 years in the last century, from 67 years in the 1920s to just 15 years today." Foster added that today's rate of change "is at a faster pace than ever" and that by 2020, more than three-quarters of the S&P 500 will be companies that we have not heard of yet.

One example of the pressure to change that companies are feeling is the pressure to become a digital business. Over the last few years a lot has been written about the necessity for businesses of all types to embark on a digital transformation.[2] The fact this isn't just an academic theory is demonstrated in the recently published book entitled *Leading Digital*[3]. The book discusses how over 400 companies in traditional industries such as finance, manufacturing, and pharmaceuticals are making that transformation.

Not surprisingly, the book entitled *Transforming to a Digital Business*[4] pointed out that one of the key characteristics of a digital business is the combination of agile business models and rapid innovation. Perhaps somewhat less obvious, the book also points out that another key characteristic of a digital business is an agile IT function.

The goal of this white paper is to highlight the technologies IT organizations are adopting in order to be more agile and position themselves to support the range of business changes they are making.

The Traditional IT Infrastructure

As described in *The Mandate for a Highly Automated IT Function*[5], the key characteristics of a traditional IT infrastructure that cause the infrastructure to be both expensive and slow to respond to new requirements are that the traditional infrastructure:

- Is hardware centric
- Focuses on dedicated servers and appliances
- Is comprised of equipment from myriad vendors and of varying vintages
- Relies on inadequate automation tools

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[1] http://www.bbc.com/news/business-16611040
[2] https://www.capgemini.com/resource-file-access/resource/pdf/The_Digital_Advantage__How_Digital_Leaders_Outperform_their_Peers_in_Every_Industry.pdf
[3] http://www.amazon.com/Leading-Digital-Technology-Business-Transformation/dp/1625272472
[4] http://www.amazon.com/Transforming-digital-business-Forum-guides-ebook/dp/B00KY57ITW
[5] http://info.qualisystems.com/the-mandate-for-a-highly-automated-it-function-0-0

The first paper in this series, *The Real Value of an SD-WAN*[6], discussed the specific characteristics of a traditional network that makes it slow to respond to new requirements. According to that paper, "In the traditional approach to networking, network functionality is implemented in a dedicated appliance; i.e., switch, router, WAN Optimization Controller. In addition, within the dedicated appliance, most of the functionality is implemented in dedicated hardware such as an ASIC (Application Specific Integrated Circuit). One of the key characteristics of the traditional approach to networking is that because of its hardware-centric focus, network functionality evolves very slowly. In addition, since each appliance is configured individually, tasks such as provisioning, change management and de-provisioning are very time consuming and error prone."

A Software Defined Data Center

In order to be more agile and to reduce cost, many IT organizations have started to adopt the key concepts of a Software Defined Data Center (SDDC)[7]. An SDDC is where the entire infrastructure is virtualized and delivered as a service, and the control of the data center is entirely automated by software. The software provides everything that's needed to adapt the data center to new situations and new applications, and to manage everything from storage to switches to security based on the policies established by the IT organization.

The left side of Figure 1 shows the compute stack that is part of an SDDC. A key component of the compute stack is server virtualization. Server virtualization involves a program called a hypervisor that facilitates multiple virtual machines (VMs) sharing a single physical host, which may or may not be a commodity server. Each VM appears to have the host's processor, memory, I/O and other resources all to itself. However, the hypervisor is actually controlling the host processor and its resources and allocating what is needed to each VM. One of the key characteristics of server virtualization is that it masks the physical servers, including the number and identity of individual physical servers, processors, and operating systems, from the users.

Running on the VMs are applications each of which in the traditional data center model would have run in its own physical server. Supporting these applications are a range of virtualized application services such as load balancing and single sign on. At the top of the compute stack is an orchestration engine whose role it is to provide full infrastructure management and automation. For example, an IT organization can set a policy that if the CPU utilization of a particular physical server reaches a pre-defined threshold, that one or more VMs should be automatically moved to a different physical server.

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[6] https://cradlepoint.com/sites/default/files/wp_-_the_real_value_of_an_sd-wan.pdf
[7] https://en.wikipedia.org/wiki/Software-defined_data_center

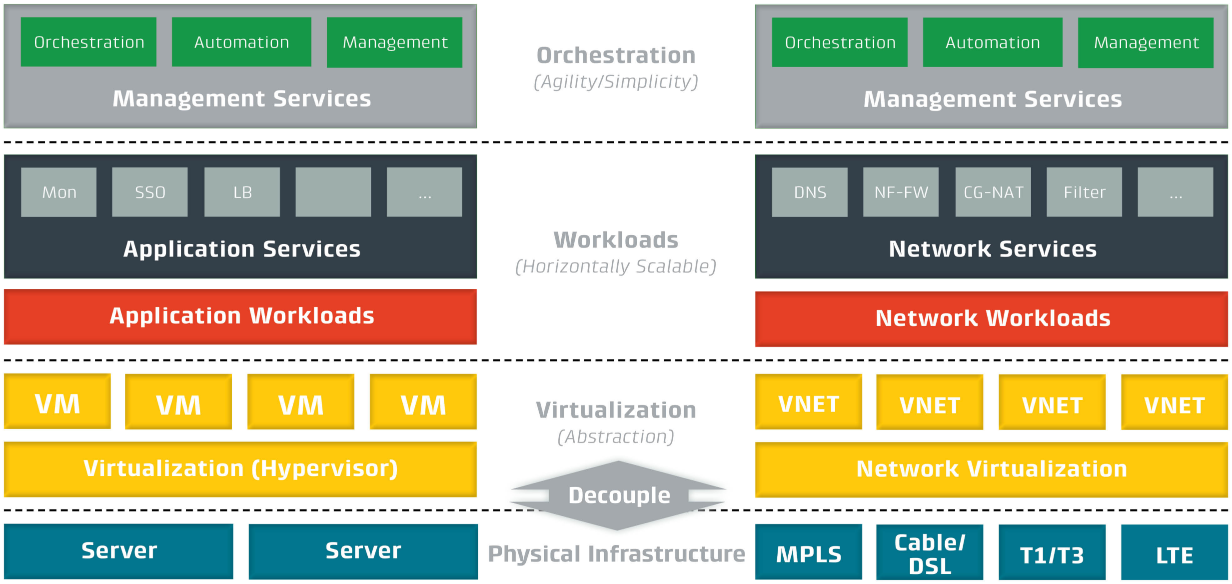

Figure 1: The Compute and Network Stacks

While not shown explicitly in Figure 1, another key component of an SDDC is storage virtualization. Storage virtualization is the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console. As previously noted, a key characteristic of the new compute stack is policy-based management. Some people refer to layering on top of storage virtualization the ability to have the provisioning of storage be automatically driven by policy as being software-defined storage.

The compute stack in Figure 1 represents the antithesis of the traditional compute stack. For example, part of the value of a SDDC is that it will enable applications to dynamically define its resource requirements in line with the company's security, compliance, and performance requirements. This will in turn facilitate more rapid application deployment and it will enable the IT function to be more responsive to business requirements.

Another important aspect of the new computing stack is that the decoupling of the physical infrastructure layer from the software-based computing infrastructure has enabled the ability to host computing anywhere and deliver it as a service (Infrastructure-as-a-Service or IaaS). This new computing modality has given rise to the public cloud and has created a new generation of IT juggernauts, such as Amazon Web Services (AWS).

Virtual Networks and Virtual Network Functions

The right side of Figure 1 is the emerging networking stack. Whereas the compute stack is applicable primarily inside a data center, as discussed in *The Real Value of an SD-WAN,* the changing networking stack is applicable inside the data center, in the WAN, and in branch and campus networks.

The Real Value of an SD-WAN discussed how Software Defined Networking (SDN) fundamentally changes how networks evolve as well as how they are built and managed in a way that leads to networks being dramatically more agile and more efficient. That paper examined the virtualization layer shown in Figure 1 and discussed how the abstraction that is inherent in SDN enables network services such as end-to-end virtual networks (VNETs) to be abstracted from the underlying infrastructure in a manner similar to how server virtualization enables compute resources to abstracted from the details of the underlying physical servers. Network virtualization isn't a new topic. IT organizations have implemented various forms of network virtualization for years; i.e., VLANs, VPNs, and VRF. However, while these forms of virtualization provide value, they don't represent the same level of fundamental change and provide as much value, as does the network virtualization layer in Figure 1. One of the key characteristics of this new network virtualization layer is that it is about networks within networks. As a result, this new layer provides users with the ability to have full abstraction from topology (e.g., mesh over spoke and hubs), addressing (e.g., IPv6 over IPv4), protocol (e.g., TCP over UDP, TCP over TCP, UDP over UDP, Ethernet over UDP, etc.) and services.

Missing from *The Real Value of an SD-WAN* was a discussion of the network services that are the equivalent of the application services in the workload layer in Figure 1. These services include:

- Domain Name Service (DNS)
- Next Generation Firewalls (NG-FW)
- Carrier-Grade NAT (CG-NAT)
- Intrusion Detection Systems/Intrusion Protection Systems (IDS/IPS)
- WAN Optimization
- Authentication, Authorization, and Accounting (AAA) functionality

In a traditional networking environment implementing these services is cumbersome and time consuming as it requires acquiring the requisite dedicated network appliances and cabling them together in the correct order. Since each appliance has its own unique interface, configuring these appliances is an error-prone task. In addition, IT organizations have two alternatives relative to sizing these appliances. They can either size the appliances for the anticipated peak load over an extended period of time or they can resize the appliances on a regular basis to account for shifts in the traffic load. The first alternative results in stranded capacity and the second alternative results in an increase in the amount of manual labor that is required.

Similar to what is happening with application services, what is needed in the network stack is a way to decouple network functions such as the ones listed above from the dedicated hardware on which they have traditionally run. For the last several years, this is a topic that has been closely associated with Communications Service Providers (CSPs), who refer to this topic as Network Functions Virtualization (NFV).

However, while CSPs typically have a broader range of functionality that they are interested in virtualizing than do enterprises, enterprise IT organizations have been implementing virtualized functionality for several years; e.g. virtualized WAN optimization controllers and virtualized

Application Delivery Controllers. While the European Telecommunications Standards Institute[8] (ETSI) champions the interest that CSPs have with virtualizing network functions, the Open Networking User Group (ONUG)[9] is one of the organizations that has emerged to champion the corresponding interest that enterprises have with implementing automated virtualized functionality.

ONUG was founded in 2012 and unlike ETSI its members are primarily enterprise companies such as Fidelity Investments, Citigroup and FedEx. In a white paper entitled *Open Networking Challenges and Opportunities*[10], the group discussed the cost and complexity of managing a large number of Layer 4 - 7 network appliances from different vendors with different management tools. In that white paper ONUG used the phrase *Network Services Virtualization* (NSV) to refer to the virtualization of functions such as the ones listed above. The paper also stated that the NSV use case "Seeks to leverage the flexibility and low costs of commodity servers to establish a scale-out pooling of virtual and physical appliances, which can be put to use servicing applications." ONUG went on to say that as Layer 4 - 7 functions are virtualized, it provides the following benefits:

- Lower CAPEX costs
- Rapid service provisioning
- Reduced risk through service distribution
- Eased management and reduced operational costs
- Consistent policies across different Layer 4-7 services and across data center, campus, and WAN networks
- Programmatic control and ability to offer network functions as a service to developers

ONUG added that another potential benefit of NSV is the ability for IT business leaders to deliver on-demand or self-service IT delivery to business unit managers.

There clearly are differences between what ETSI is trying to accomplish with NFV and what ONUG is trying to accomplish with NSV. For example, CSPs hope to virtualize some functionality that few if any enterprise organizations implement and their need for scale far surpasses what is needed by the vast majority of enterprise organizations. In addition, CSPs are notably more likely to have a requirement to link the usage of virtualized network functions to their billing systems than do enterprise organizations. However, if you change at most a few words in how ONUG describes the NSV use case it sounds exactly like what ETSI and others are trying to achieve with NFV. The bottom line is that it is time to recognize that the phrase NFV covers a range of activities that are applicable both to CSPs and to enterprises.

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[8] http://www.etsi.org/news-events/news/644-2013-01-isg-nfv-created
[9] https://opennetworkingusergroup.com/
[10] http://opennetworkingusergroup.com/wp-content/uploads/2014/06/ONUG-WhitePaper-7_14_V6.pdf

As is the case with the new computing stack, a key characteristic of the new networking stack is the decoupling of the physical network infrastructure from the software-based networking infrastructure. This decoupling is enabling a new generation of software-defined networks and networks services, which are hosted in the public cloud and delivered as a service (Network-as-a-Service or NaaS). Cradlepoint's NetCloud Engine service, which is based the acquisition of Pertino and its cloud networking platform, is an example of a NaaS that incorporates NFV/NSV functionality.

Summary

Companies of all types and sizes are feeling pressure to become a digital business. In order to achieve that goal, companies need to adopt agile business models that enable them to continually innovate. One of the key factors that limit a company's ability to adopt agile business models is the traditional hardware-centric IT infrastructure that is both expensive and slow to respond to new requirements.

Driven in large part by the need to enable business agility, the traditional hardware-centric compute and networking stacks are being redefined into a four layer model the goal of which is to lower the cost and increase the agility of both compute and networking. Those four layers are:

- Layer 1: Physical infrastructure

  In the case of the compute stack, this refers to servers. In the case of the network, this refers to any wired or wireless IP network.

- Layer 2: Virtualization

  This enables VMs and VNETs to be abstracted from the underlying physical infrastructure.

- Layer 3: Workloads

  In addition to the application and network workloads, this layer also consists of application and network services such as single sign on and next generation firewalls.

- Layer 4: Orchestration

  At the top of each stack is an orchestration engine the role of which is to provide full management and automation of the stack.

While the compute stack is applicable primarily inside a data center, the networking stack is applicable inside the data center, in the WAN, and in branch and campus networks.

In addition to next generation firewalls, the network services that are included in Layer 3 of the new networking stack include additional security functionality such as IDS/IPS, WAN optimization functionality such as de-duplication and a variety of enabling services such as DNS and CG-NAT. It is somewhat common to refer to the virtualization and automation of services such as these as being NFV and associate the interest in NFV as being limited to CSPs. The reality is that enterprises have been implementing virtualized services for several years and driven by the work of industry groups such as ONUG, an array of products and services are being brought to market that enable organizations to implement fully featured versions of the new networking stack.