The Promise and the Reality of a Software Defined Data Center

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Introduction

The traditional IT operational model is highly manual and very hardware centric. As a result, IT infrastructure services have historically been both expensive to provide and slow to respond to new requirements. Over the last few years, the pressure that virtually all IT organizations have felt to reduce cost and to be more responsive to new business requirements has driven both the adoption of new technologies, such as server virtualization, and the adoption of new ways of delivering IT services, such as cloud computing.

This white paper is part of a five-part series of white papers and webinars that describe the journey that IT organizations must take to go from the traditional highly manual, hardware centric IT operational model to an operational model that is highly automated, software centric and which reduces both the cost of IT infrastructure services as well as the time it takes to implement those services. This white paper will focus on a key component of that journey: the software defined data center (SDDC). The previous white paper in this series, *The Mandate for a Highly Automated IT Function*[1], described many of the pieces that comprise a SDDC. The primary goals of this white paper are to describe the market maturity of each of those pieces and to identify the factors driving and inhibiting adoption.

Software Defined Data Centers

As described in *The Mandate for a Highly Automated IT Function*, 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.

A SDDC represents the antithesis of the traditional IT infrastructure. For example, part of the promise 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. The deployment of a SDDC may well reduce CAPEX and/or OPEX, but it is too early in the development and deployment of a SDDC to be able to predict how much of a reduction, if any, will occur.

The two primary characteristics of a SDDC are virtualization and automation. In particular, in a SDDC:

- Computing, storage and networking are virtualized and are all pooled resources;

[1] http://www.qualisystems.com/white_papers/the-mandate-for-a-highly-automated-it-function-2/

- There are programmatic interfaces into all of the data center resources;
- Automated management delivers a framework for policy-based management of data center application and services.

The successful adoption of a SDDC will require more than just the adoption of new technologies. It will also require that IT organizations make significant progress towards eliminating the barriers that typically exist between the various technical domains; e.g., network, compute, storage. The skill set of IT organizations will also have to change as IT organizations will need relatively fewer people to perform manual tasks such as configuration management and will require more people that are skilled in automation. In addition, as described below, IT organization will have to adopt more agile processes such as DevOps.

At this point in time, a SDDC is an aspirational goal as few, if any, IT organizations have currently implemented a SDDC. However, as described below, the majority of IT organizations have already taken steps that lead them to a SDDC; e.g., implementing server virtualization.

Cloud Computing

As pointed out in The 2013 Application and Service Delivery Handbook[2], the two primary factors driving IT organizations to either utilize applications and services from a cloud computing service provider, or to provide applications and services in a similar fashion themselves are to lower cost and to reduce the amount of time it takes to implement an application or to add capacity.

One measure of the large and growing adoption of cloud computing is that according to industry analysts, the global cloud computing market will grow to $241 billion in 2020[3]. While the adoption of cloud computing has great potential, to date the companies that have made the most use of cloud computing have typically been small and mid-sized companies. It is just over the last eighteen months that large enterprises have begun to adopt cloud computing in a meaningful way.

There are several technical inhibitors to the increased adoption of cloud computing including concerns about security, compliance and performance. It is also very difficult to move workloads both from an enterprise to a cloud provider as well as between cloud providers. In addition, today most cloud orchestration tools focus on fully virtualized environments, which are few in number.

Server Virtualization

Of all of the steps that lead to a SDDC, server virtualization is the most widely adopted. For example, according to the 2013 Application and Service Delivery Handbook, the majority of IT organizations have implemented at least some server virtualization and the amount of server virtualization is expected to increase over the next few years.

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[2] http://www.webtorials.com/content/2013/06/2013-application-service-delivery-handbook.html
[3] http://www.zdnet.com/blog/btl/cloud-computing-market-241-billion-in-2020/47702

One of the advantages of server virtualization is that it makes it easy to move virtual machines (VMs) between physical servers. However, when a VM is moved between servers, the VM needs to be on the same VLAN after it was moved as it was on prior to the migration. Extending VLANs across a data center in order to support VM mobility adds to the operational cost and complexity because it requires that each switch in end-to-end path be manually reconfigured. This networking requirement limits the amount of agility that is provided by server virtualization. Overcoming this situation is one of the primary drivers of network virtualization which is discussed below.

Today few large enterprises have virtualized all of their data center servers. Some of the factors that limit the adoption of server virtualization include:

- Some providers of enterprise software don't support it;
- Some servers can't be virtualized;
- Concerns over security
- Concerns over performance

Storage Virtualization

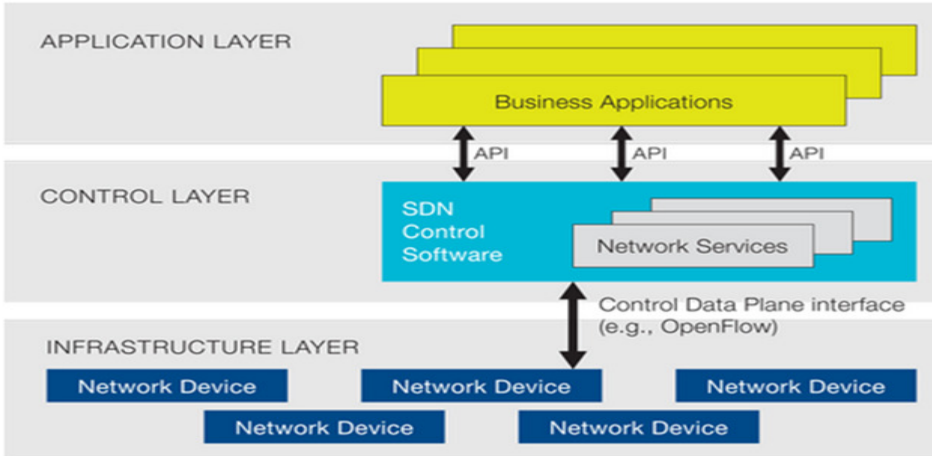
Storage virtualization is the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console. There are many factors driving the adoption of storage virtualization. One of those factors is the CAPEX savings that result from being able to increase storage utilization. Storage virtualization also reduces OPEX by enabling the storage administrator to perform the tasks of backup, archiving, and recovery more easily and in less time by masking the complexity of a storage area network (SAN). This has the added benefit of improving an IT organization's disaster recovery capabilities.

As previously noted, a key characteristic of a SDDC is policy-based management of data center applications and services. A related concept is software defined storage which layers on top of storage virtualization the ability to have the provisioning of storage be automatically driven by policy. According to the 2013 Information Week State of Storage survey[4], 41% of IT organizations have put at least some of their storage systems into a virtual pool. While storage virtualization has been relatively widely adopted, software defined storage products are just beginning to be offered to the marketplace.

Software Defined Networking (SDN)

A SDN is an emerging architecture that decouples the network control and forwarding functions and centralizes at least some of the control functions into a device referred to as a controller as shown in Figure 1.

[4] http://reports.informationweek.com/abstract/24/9898/Storage-Server/Research:-2013-State-of-Storage.html



SDN Architecture
Figure 1

The 2013 Guide to Network Virtualization and Software Defined Networking[5] contains the results of a survey in which the survey respondents were given a number of possible approaches and were asked to indicate which approach or approaches their company is taking relative to the adoption of SDN. The two most common answers were:

- We are currently actively analyzing the potential value that it offers (36%);
- We will likely analyze it sometime in the next year (26%).

Table 1 is based on the survey data and it shows how broadly SDN is currently deployed both in production networks as well as in labs and limited trials. Table 1 also shows the interest that the survey respondents have in implementing SDN sometime over the next year.

Approach to SDN	Percentage of Respondents
We currently are running SDN somewhere in our production network	6%
We currently are running SDN either in a lab or in a limited trial	13%
We expect that within a year we will be running SDN somewhere in our production network	10%
We expect that within a year we will be running SDN either in a lab or in a limited trial	19%

Table 1: Approaches to SDN

One conclusion that can be drawn from the survey data is that 2014 will not be the year of SDN. However, it certainly is possible that 2014 will be the year of the SDN Proof of Concept (POC).

[5] http://www.webtorials.com/content/2013/10/2013-guide-to-software-defined-networking-network-virtualization.html

Network Virtualization

Network virtualization isn't a new concept. VLANs have been widely deployed for over a decade. The advent of SDN has spawned new ways of implementing network virtualization. For example, one way that network virtualization can be implemented is as an application that runs on a SDN controller, leverages the OpenFlow protocol to communicate with the network elements, and defines virtual networks based on policies that map flows to the appropriate virtual network using the L1 - L4 portions of the packet header. This fabric-based approach is in line with the SDN architecture that is shown in Figure 1.

Another way that network virtualization can be implemented is by using techniques such as encapsulation and tunneling to construct multiple virtual network topologies overlaid on a common physical network. This overlay approach is depicted in Figure 1.

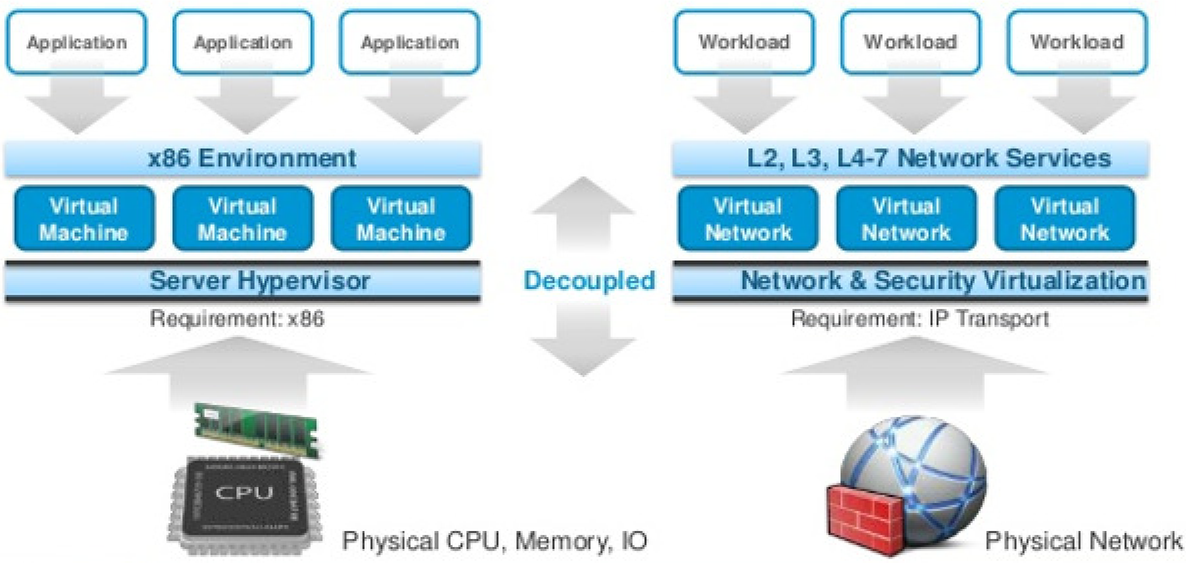


Figure 2: Network Virtualization via Overlays Source: VMware

Similar to what was said about SDN in general, 2014 will not be the year of network virtualization but it is certainly possible that 2014 will be the year of the network virtualization POC.

Network Function Virtualization

While server virtualization was the first form of virtualization to significantly impact IT organizations, today most IT organizations have implemented additional forms of virtualization including the virtualization of appliances such as WAN Optimization Controllers (WOCs) and Application Delivery Controllers (ADCs). Related to the virtualization of L4 – L7 devices is that most SDN solutions implement *service chaining* which refers to the ability of the solution to dynamically steer traffic flows through a sequence of physical or virtual servers that provide L4 – L7 services.

In November 2012 the European Telecommunications Standards Institute (ETSI) formed an Industry Specifications Group for Network Functions Virtualization (NFV ISG). The goal of NFV ISG is to enable telecommunications service providers to greatly simplify their operations and reduce capital expense by having all of the network functions they use available as virtual appliances that can be easily provisioned and integrated regardless of the vendor who provided the appliance or the hypervisor(s) on which it runs. In October 2013, ETSI published the first of what is expected to be several publications intended to standardize NFV[6]. These documents identify an agreed-to framework and terminology for NFV.

The market maturity of NFV depends on what is meant by NFV. If *NFV* refers just to the virtualization of network functionality such as WOCs and SDCs, then that market is relatively well developed and will continue to develop over the foreseeable future. If *NFV* refers to SDN-based service chaining, then as previously discussed, that market is largely in the analysis and POC stage of evolution. If NFV refers to the work of the NFV ISG, then the market is years away.

Management

One of the management challenges brought on by virtualization of IT resources such as compute, storage and networks is that the IT organization tends to loose visibility into the use of those resources. In addition, each form of virtualization brings its own unique management challenges. The advent of SDN, for example, creates a new management challenge – managing the SDN controller. There are also management challenges that are inherent in any IT environment whether that environment is hardware or software centric. For example, management products tend to be both technology-specific and vendor-specific.

Unfortunately, the capability to manage new IT functionality typically trails the development of that functionality. Cloud Orchestration platforms are a good example of that phenomena. These platforms have evolved over the last few years as a means of automating and facilitating the process of configuring pools of data center resources in order to provide a range of cloud services. The Cloud Orchestrator's role is to manipulate the basic resources of the data center (i.e., VMs, networks, storage, and applications) at a very high level of abstraction to create the service. However, even though cloud computing has been a force in the marketplace for several years, cloud orchestration solutions tend to be effective only when the data center is fully virtualized, which is a rare situation. It is extremely likely that effective management tools will continue to trail the development of all of the functionality that will be required to enable the new IT operational model; e.g., a SDDC.

Automation

One of the biggest impediments to implementing the level of automation that is required by a SDDC is that while many components of a data center are becoming software based, the typical

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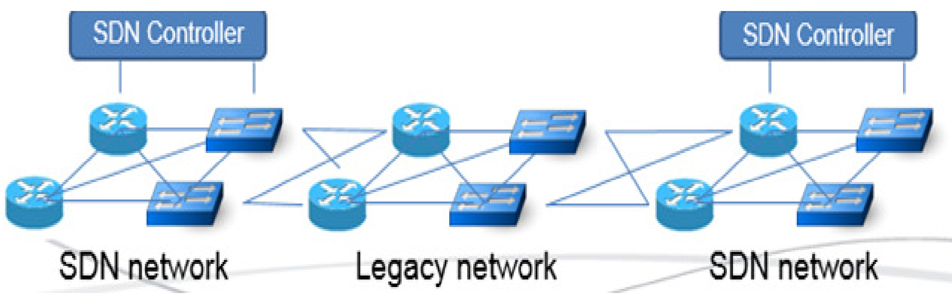
[6] http://www.etsi.org/news-events/news/700-2013-10-etsi-publishes-first-nfv-specifications

existing data center will not become fully software based for the foreseeable future. One of the reasons for this is that over time IT organizations have made massive investments in technology which have resulted in the typical data center being comprised of multiple generations of products. IT organizations cannot afford to merely write-off these investments and most of the products cannot be easily upgraded to support virtualization.

Even though data centers will not be fully software based anytime soon, IT organizations still need to be able to automate their data centers as much as possible. Figure 3 depicts a data center that houses two SDNs and those SDNs have to interoperate with the legacy components of the data center network. Complicating the challenge of interoperating SDN and legacy networks is the fact that the tools that IT organizations use to automate network functionality, whether those networks are SDNs or legacy networks, tend to be specific to the vendor who supplied the network.



Combined SDN Legacy Network
Figure 3

The challenge depicted in Figure 3 is repeated for each technology domain. For example, virtualized servers need to interoperate with both physical servers and mainframes and virtualized storage has to interoperate with storage that is not virtualized. As was the case with networking, the tools that IT organizations use for automating compute and storage tend to be vendor-specific. In addition, the technology domains have to all work together. This means that IT organizations need to automate a data center that is comprised of a wide range of technologies that exhibit varying degrees of virtualization and that are provided by a large set of vendors. Further complicating the challenge of automating application and service delivery is that some IT organizations have deployed infrastructure that is specific to their industry. An example of that is the highly-automated factory floors that are common in manufacturing. A highly-automated factory floor may or may not be considered a data center in the traditional sense of data center. Independent of that, these industry-specific infrastructures exhibit the same characteristics as a data center (i.e., multiple technologies, combination of physical and virtualized products) and the same need for increased automation.

Currently the most common approach to automation is to use scripts. As described in *The Mandate for a Highly Automated IT Function*, this approach has some significant limitations including that scripts:

- Are difficult and time consuming to maintain;

- Break when there is a change in the environment;
- Require scarce programmers;
- Are difficult, if not impossible, to reuse.

DevOps

The phrase *DevOps* is a result of bringing to together two phrases: *Development* and *Operations*. That's appropriate because the point of adopting DevOps is to establish tight collaboration between a number of the phases of the application development lifecycle, including application development, testing, implementation and ongoing operations. DevOps is not a technology, but an approach. Some of the key characteristics of the approach are that the applications development team writes primarily small incremental pieces of code that are tested on an architecture that reflects the production architecture. Ideally, the network on which the software is tested will reflect not just the architecture but also the same characteristics (i.e., delay, packet loss) as the production network.

Implementing DevOps provides many advantages. For example, DevOps can provide business value by enabling companies to experience sustained innovation[7]. Examples of companies that claim to have experienced sustained innovation as a result of implementing DevOps include Twitter, Netflix and Facebook. Implementing DevOps has other advantages. According to a recent Information Week Report[8], eighty two percent of the IT organizations that implemented DevOps saw at least some improvement in infrastructure stability and eighty three percent saw at least some improvement in the speed of application development.

Although DevOps provides clear business and technical value, the Information Week Report highlights the fact that only a relatively small minority of IT organizations have embraced DevOps. According to that report, sixty-eight percent of IT professionals are aware of DevOps and of those who are aware of it, only twenty-one percent have currently embraced it.

Summary and Conclusions

The path that IT organizations will take to move away from the traditional IT operational model and towards an IT operational model that can respond quickly to new requirements and which is relatively inexpensive has several steps. Some of those steps, such as server virtualization and cloud computing are well underway. SDDC, in contrast, is in its infancy.

Implementing a SDDC will require the adoption of a number of technologies. It will also require changes to the skill sets found in the typical IT organization and it will also require changes to the organization's processes such as the adoption of DevOps. Automation is one of the key technical enablers of a SDDC. However, in order to effectively implement a SDDC or many of

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[7] http://dev2ops.org/2012/09/use-devops-to-turn-it-into-a-strategic-weapon/

[8] http://www.informationweek.com/strategic-cio/executive-insights-and-innovation/state-of-devops-big-gains-elusive/d/d-id/1113307

the components of a SDDC, IT organizations must choose automation tools that work across all of the multi-generational technologies and all of the vendors that are typically found in a data center or other IT-intense environment, such as a highly-automated factory floor. Unfortunately the vast majority of traditional automation tools have many limitations including the fact that they can’t handle a heterogeneous, multi-generational infrastructure.

Given the importance of adopting a new IT operational model, IT organizations can’t afford to sit on the sidelines waiting for all the pieces to be in place before acting. A better approach is focus on functionality such as automation, which has broad applicability in both the current and the emerging IT operational model, and begin to implement automation tools that don’t have the same limitations as do the current generation of script-based tools. Relative to enabling the adoption of a SDDC, one option is to apply these automation tools to overcome some of the issues associated with cloud computing. Another option is to apply these automation tools during application development, testing and deployment and hence take a major step towards the adoption of DevOps.