The 2013 Guide to Network Virtualization and SDN

Part 4: Planning for Network Virtualization and SDN

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Executive Summary

Over the last year, the hottest topics in networking have been Network Virtualization (NV) and Software Defined Networking (SDN). There is, however, considerable confusion amongst enterprise IT organizations relative to these topics. There are many sources of that confusion, including the sheer number of vendors who have solutions that solve different problems using different solution architectures and technologies, all of whom claim to be offering SDN and/or NV solutions.

The primary goal of the ***2013 Guide to Software Defined Networking & Network Virtualization*** (The Guide) is to eliminate that confusion and accelerate the adoption of NV and/or SDN. The guide will achieve that goal by walking the readers through the following set of topics:

1. What are the problems and opportunities that NV and SDN help to address?
2. What are the primary characteristics of NV and SDN solutions?
3. How does NV and SDN help IT organizations respond to problems and opportunities?
4. How are IT organizations approaching the evaluation and deployment of NV and/or SDN?
5. What is the role of organizations such as the ONF and the OpenDayLight consortium?
6. What approach are the key vendors taking relative to NV and SDN?
7. What should IT organizations do to get ready for NV and SDN?

The Guide will be published both in its entirety and in a serial fashion. This is the fourth of the serial publications. The first publication focused on NV; the second publication focused on SDN; and the third publication focused on the NV and SDN ecosystem[1]. The goal of this publication is to create an outline that IT organizations can use to plan for the adoption of SDN and NV.

In August and September of 2013 a survey was given to the subscribers of Webtorials. Throughout this document, the IT professionals who responded to the surveys will be referred to as *The Survey Respondents*.

[1] webtorials.com/Metzler

Introduction

As noted in the executive summary, there is considerable confusion in the industry relative to NV and SDN. This confusion is understandable given the breadth of problems that these solutions are supposed to address combined with the variety of approaches that vendors are proposing. Further adding to the confusion is the embryonic nature of most of the solutions that are available in the marketplace, the current limited adoption of these solutions and the overall level of hype associated with NV and SDN.

Given this confusion, it would be understandable if an enterprise IT organization decided to take a wait and see attitude about NV and SDN. While that response would be understandable, it isn't the right approach to take either from the perspective of the IT organization or the IT professional. That follows in part because even though no reasonable person would claim to know in detail how SDN and network virtualization will evolve over the next several years, there is no doubt that:

- IT organizations need to solve the problems (e.g., support the dynamic movement of virtual machines, reduce operational complexity) that NV and SDN are designed to solve.

- Many of the characteristics of NV and SDN solutions (e.g., more reliance on software, increased use of automation) are already being broadly adopted within IT organizations.

There is also no doubt that implementing NV and/or SDN presents risk, but that ignoring NV and SDN presents significant risk to both enterprise IT organizations and to IT professionals. The risk to enterprise IT organizations is that by ignoring NV and SDN they remain unable to solve the problems that NV and SDN are designed to solve and this puts their company at a competitive disadvantage. The risk to IT professionals is that ignoring NV and SDN delays their coming up the learning curve on these new approaches which would result in a diminishment of the value they could provide either to their current employer or to a future employer.

Market Research: The Current State of Planning

This subsection of The Guide presents recent market research that quantifies:

- How IT organizations are approaching analyzing and implementing NV and SDN;
- The plans that IT organizations have for open source solutions and open protocols;
- The expectations that IT organizations have for how broadly they will implement NV and SDN.

How IT organizations are Approaching NV and SDN

The Survey Respondents were asked to indicate the approach that their company is taking relative to adopting NV and SDN. The Survey Respondents were allowed to indicate multiple approaches and a summary of their responses is shown in **Table 1**.

Table 1: Approach to Implementing NV and SDN

Approach	NV	SDN
We have not made any analysis of it	26%	19%
We will likely analyze it sometime in the next year	26%	26%
We looked at it and decided to not do anything with it over the next year	6%	5%
We are currently actively analyzing the potential value that it offers	25%	36%
We are currently actively analyzing vendors' strategies and offerings for it	12%	20%
We expect that within a year that we will be running it either in a lab or in a limited trial	14%	19%
We currently are running it either in a lab or in a limited trial	10%	13%
We expect that within a year that we will be running it somewhere in our production network	6%	10%
We currently are running it somewhere in our production network	7%	6%
Don't know	5%	4%
Other	1%	4%

The way to read the data in **Table 1** is that 26% of The Survey Respondents work for companies that haven't made any analysis of NV and 19% of The Survey Respondents work for companies that haven't made any analysis of SDN.

While there are some differences between the overall approach that IT organizations are taking to NV and the overall approach that IT organizations are taking to SDN, there are more similarities than there are differences. The high level story told by the data in **Table 1** is that today there is a lot of interest in both NV and SDN, but very little deployment of either in

production networks. If The Survey Respondents are correct, there will be a modest increase in the production use of both NV and SDN in 2014.

The Expected Role of Open Source and Open Protocols

Given that the phrase *open networking* is often associated with SDN, The Survey Respondents were asked to indicate the type of SDN solution that their organization was likely to implement within the next two years and the possible responses focused on open protocols and open source solutions. The respondents were only allowed one choice. Their responses are shown in **Table 2**.

Table 2: Likely SDN Solutions

Selection	% of Respondents
Open source, open protocols, multiple vendors	21%
Open source, open protocols, single vendor with an ecosystem of partners	12%
A mix of open and proprietary protocols based on a single vendor with its ecosystem of partners	22%
Most attractive solution regardless of openness or number of vendors	17%
It is unlikely that we will implement SDN within two years	15%
Don't know	12%

One conclusion that can be drawn from **Table 2** is that in spite of all of the discussion of open networking on the part of press and analysts, less that half of The Survey Respondents who work for a company that will likely implement SDN within the next two years are currently committed to SDN solutions based on open source and open protocols[2].

[2] The Survey Respondents who answered "don't know" were excluded from the calculation.

Anticipated NV and SDN Deployment

The Survey Respondents were asked to indicate how broadly they expected that their campus, WAN and data center networks would be based on SDN and/or NV three years from now. The question didn't make any attempt to define how network virtualization would be implemented; e.g., as part of an overlay solution or through manipulating OpenFlow tables. Their responses are shown in **Table 3** and **Table 4**.

Table 3: Expected Deployment of NV

	Exclusively Based on NV	Mostly NV	Hybrid – NV and Traditional about Equal	Mostly Traditional	Exclusively Traditional	Don't know
Campus Networks	1%	12%	40%	24%	10%	14%
WAN	0%	7%	35%	32%	11%	14%
Data Center Networks	3%	25%	38%	17%	4%	13%

Table 4: Expected Deployment of SDN

	Exclusively Based on SDN	Mostly SDN	Hybrid – SDN and Traditional about Equal	Mostly Traditional	Exclusively Traditional	Don't know
Campus Networks	2%	14%	42%	26%	7%	10%
WAN	2%	10%	35%	35%	10%	8%
Data Center Networks	3%	28%	39%	18%	5%	7%

Some of the conclusions that can be drawn from the data in **Table 3** and **Table 4** include:

- Although The Survey Respondents expressed the strongest interest in deploying NV and SDN in their data centers, they also expressed significant interest in deploying NV and SDN in both campus and wide area networks.

- Only a small percentage of The Survey Respondents indicated that in three years that their networks would be either based exclusively on traditional techniques or exclusively on NV and/or SDN.

- The Survey Respondents' most common response was that three years from now that each type of network would be comprised roughly equally of a traditional approach and an approach based on NV and/or SDN.

Crafting an NV and/or SDN Plan

This section of The Guide outlines a process that a hypothetical company, that will be referred to in this section as *GottaChange,* can use to plan for the implementation of NV and/or SDN. The intention is that IT organizations will customize this process for use in their environments.

Define NV and SDN

As described in previous chapters of The Guide, there isn't uniform agreement in the industry as to the precise definition of NV and/or SDN. *GottaChange* can't wait for the brouhaha surrounding the definition of NV and SDN to sort itself out. As part of developing an implementation plan, *GottaChange* must develop a definition of NV and/or SDN that is well understood and agreed to within their organization.

Identify the Primary Opportunities

In order to intelligently choose vendors, architectures and enabling technologies, *GottaChange* needs to first identify the primary opportunities that they are hoping to address by implementing NV and/or SDN. To assist with this process, Chapter 1 of The Guide identified the primary use cases for NV and also presented market research that showed the interest that The Survey Respondents had in each of the use cases. Chapter 2 did the same for SDN.

To exemplify the relationship between the opportunities and the various solutions being proposed by vendors, consider the fact that if the primary opportunity that is driving an IT organization is the need to support the dynamic movement, replication and allocation of virtual workloads, then an overlay-based NV solution from a vendor such as Nuage Networks or Netsocket is a viable candidate, as is a solution from a company such as NEC that implements NV by manipulating OpenFlow tables. An overlay-based NV solution unto itself, however, doesn't make it easier to respond to other opportunities such as making it easier to implement QoS, nor does it enable applications to dynamically request services from the network[3].

Identify the Key Metrics

Having identified the primary opportunities, *GottaChange* needs to identify the key business-related metrics that are associated with each opportunity. The principal use of these metrics is to enable the IT organization to create a business case for implementing NV and/or SDN. However, *GottaChange* should use these metrics throughout the evaluation process; i.e., evaluating solution architectures and performing a proof of concept.

In some cases the key business metrics may be obvious. For example, if one of the primary opportunities that *GottaChange* is trying to address is the centralization of configuration management and provisioning, then one of the key business metrics associated with that opportunity is likely to be labor savings. In contrast, if one of the primary opportunities is to enable business agility, it may be more difficult for *GottaChange* to identify one or more IT-related metrics that, if NV and/or SDN improve them, lead to measurable business value.

[3] Chapter 2 of The Guide discussed an overlay/underlay model that can address these opportunities.

Define the Scope of Possible Solutions

As some point in the planning process *GottaChange* needs to define how broad of an NV and/or SDN solution they are seriously considering implementing. This could come after the first phase of the evaluation process (see below). It should come prior to *GottaChange* moving forward with performing a proof of concept (POC). As described below, the broader *GottaChange* defines the potential solution, the more risk and the more organizational resistance they will encounter.

In addition, based on how *GottaChange* defines what they mean by a NV and/or SDN solution, it may or may not be possible for them to acquire a complete solution from a single vendor. For example, it is reasonable to consider a NV solution based on overlays to be a complete solution unto itself. Analogously, it is reasonable to think of one or more SDN controllers and the underlying network elements as being a complete solution. If *GottaChange* uses one or both of these approaches as their definition of an NV and/or SDN solution, then it is possible for *GottaChange* to buy a complete solution from a single vendor.

However, if *GottaChange* has an expanded definition of *solution*, it is less likely that they will be able to acquire a complete solution from a single vendor. An expanded definition of what *GottaChange* means by solution could include functionality such as orchestration; the L4 to L7 functions that are inserted into the service that is consumed by users; and the business applications that access the control information in the SDN controller.

Decide: Best of Breed vs. Systems Solution

As described above, based on how *GottaChange* defines what they mean by an NV and/or SDN solution, it may be possible for them to acquire a complete NV and/or SDN solution from a single vendor; a.k.a., a systems solution. However, even if it is possible for GottaChange to buy a systems solution they may decide to at least explore the option of buying best of breed components from varying vendors. If *GottaChange* determines that they are willing to acquire components from varying vendors, *GottaChange* must evaluate the testing that was done on both the individual components as well as the complete solution; how the solution will be updated and tested over time; and whether or not there is a *single throat to choke*.

It's reasonable for *GottaChange* to think that if they are acquiring a complete NV and/or SDN solution from a single vendor, that the solution won't have interoperability issues. While that is a reasonable thought, IT organizations still need to request details of the testing that was performed by the vendor themselves, as well as the results of any third party testing that was performed. This testing is important both to demonstrate interoperability of the components of the solution as well as to identify the performance limits of the solution.

Evaluate NV and/or SDN Solutions

The process that *GottaChange* uses to evaluate NV and/or SDN solutions should be cyclical. As part of the first stage of the evaluation process, *GottaChange* should perform a cursory evaluation of numerous vendors. The primary goal of the first stage of the evaluation process is to enable *GottaChange* to determine which solutions correspond to the opportunities that they are seeking to respond to and it also makes *GottaChange* aware of the varying approaches to SDN that the vendors have, each with their own value add. Upon completion of the first stage

of the evaluation process, *GottaChange* is in a position to eliminate vendors from consideration and to begin a more detailed analysis on a small set of vendors. As described below, the result of this detailed analysis may well be the recommendation to go forward with a POC.

When evaluating a vendor's SDN solution, IT organizations need to understand the following aspects of those solutions.

- **The Solution Architecture**

  This includes topics such as which components of the solution are provided by the vendor and which are provided by a partner; what functionality is done in hardware vs. in software; how much control is centralized in the SDN controller; what protocols are used within the solution; how the solution supports high availability and the level of abstraction that is provided by the controller's northbound API.

  In addition, *GottaChange* must evaluate the various NV and/or SDN solutions based on their ability to respond to the opportunities that the IT organization has identified. For example, assume that one of the opportunities that the *GottaChange* has identified is being able to support the dynamic movement of VMs. Given that, then as part of the evaluation of solution architectures, *GottaChange* has to identify how each solution accomplishes this.

  Chapter 2 of The Guide contains a set of 7 key questions that *GottaChange* can ask vendors about the architecture of their SDN solutions.

- **The Controller**

  GottaChange must evaluate the architecture of a number of NV and/or SDN controllers. For example, does the controller have a modular architecture that will enable the addition of new functionality over time? *GottaChange* also needs to understand how the controller's architecture enables scalability, high availability and performance. At the author's web site[4] is a white paper that discusses ten criteria that IT organization should use to evaluate SDN controllers[5].

- **The Network Elements**

  Most overlay-based NV solutions are network agnostic. If that is the type of solution that *GottaChange* is evaluating, then it is highly likely that there isn't a need for them to evaluate the network elements on which the potential NV solutions run.

  However, if *GottaChange* is evaluating solutions that closely resemble the ONF definition of SDN that was presented in Chapter 2, then *GottaChange* should ask the vendors questions such as:

  1. Which switches, both virtual and physical, support your SDN solution? For OpenFlow-enabled switches, identify whether the switch is a pure OpenFlow switch or a hybrid OpenFlow switch.

[4] www.ashtonmetzler.com
[5] Ibid.

2. What protocols do you support between the control layer and the infrastructure layer of your proposed solution? What network behaviors are enabled by these protocols and what types of services can be constructed using those behaviors?

3. If Open Flow is supported, what versions have been implemented? What required features of the supported version are not included in the implementation? Indicate which of the optional features it supports. Describe any significant vendor-specific extensions that have been made.

4. If one of the switches in your proposed solution is in SDN mode, are there any types of traffic that must be processed partially in software before being forwarded?

5. If one of the switches in your proposed solution is in hybrid mode, does that have any impact on the behavior of the traditional component of the switch? If yes, explain.

- **Management**

  There are two aspects of NV and/or SDN management that *GottaChange* needs to evaluate. One aspect is the ability of the vendor's solution to alleviate the management challenges created by NV and/or SDN. Based on the type of solution that *GottaChange* is considering, this may include monitoring the performance of the controller; providing end-to-end visualization of the virtual networks; configuring the SDN switches and monitoring the physical and logical networks between switches. The second aspect of management that *GottaChange* needs to evaluate is the integration of the management of NV and/or SDN into a broader management solution.

  Chapter 2 of The Guide contains a set of 5 key questions that *GottaChange* can ask vendors about the management of their SDN solutions.

- **Security**

  There are also two aspects of security that *GottaChange* needs to evaluate. One aspect is what functionality the vendor provides in order to secure their NV and/or SDN solution. One of the reasons this is important is because the NV and SDN controllers are new attack surfaces. The other aspect of security that needs to be evaluated is the ability of the solution to enhance the overall security of the IT infrastructure. An example of how SDN can potentially improve security is Radware's recent contribution to the Open DayLight consortium's SDN controller of a toolset that can be used for the detection and mitigation of DDoS attacks.

  Chapter 2 of The Guide contains a set of 5 key questions that *GottaChange* can ask vendors about the security of their SDN solutions.

- **Additional Functionality**

  There are two approaches that an IT organization can take relative to implementing network functions that ride on the SDN controller. One approach is to acquire the network functions from a vendor. Two examples of vendor provided network functions were already discussed. One is Radware's DDoS application and the other is NEC's Virtual Tenant Networking functionality. Since most IT organizations will acquire network functions from

vendors, evaluating vendor supplied network functions is a key component of the overall process of evaluating SDN solutions.

The second approach is for the IT organization to develop some or all of the required network functionality itself. The primary advantage of this approach is that it enables the IT organization to customize the network functions to meet the organization's specific requirements. One of the disadvantages of this approach is that it requires the IT organization to have the base of skills that are necessary both to develop the network functions and to maintain those functions over their life cycle.

GottaChange should use the process of evaluating NV and/or SDN solutions to determine if it can acquire all of the network functions it needs to respond to the opportunities that it has identified or if it has to develop some or all of those functions itself.

Test and Certify Solutions

As previously discussed, even if all of the components of an NV or SDN solution come from a single vendor, as part of evaluating those solutions *GottaChange* needs to understand the testing that was done to ensure both the smooth operation and the performance of the solution. Particularly in those situations in which the components of the SDN solution come from multiple vendors, *GottaChange* needs to understand if the solution is certified. By that is meant, if *GottaChange* implements the solution, will it have a single point of contact to resolve any problems that develop.

There may be instances in which *GottaChange* has to either do testing itself or to commission a third party to do testing on its behalf. For example, if *GottaChange* were to develop one or more network functions, it would need to test the operation of those functions on the controller(s) that it had selected and it would need to redo that testing prior to implementing new versions of the controller or new versions of the network functions. If *GottaChange* anticipates facing a situation like this then as part of the evaluation process, *GottaChange* needs to evaluate both the tools that are available to enable the organization to do the testing itself as well as the functionality provided by external test labs.

Integrate with the Existing Environment

It is certainly possible for *GottaChange* to evaluate NV and/or SDN solutions in isolation from the IT organization's current environment. However, given that the NV and/or SDN solution might at some time be implemented in *GottaChange's* production network, then as part of the evaluation process *GottaChange* should examine how the SDN solution would fit into the existing infrastructure. For example, what mechanisms exist to enable traffic to flow between the SDN solution and the traditional network? Is it possible to extend the SDN solution so that it operates both in a data center and in a branch office? So that the solution operates in multiple data centers?

Educate the Organization

Both NV and SDN are both embryonic and rapidly evolving. Hence, in order to create and update a plan to potentially implement one or both of these architectures, *GottaChange* must continually educate itself as to what is happening in the broad NV and/or SDN ecosystem. This

certainly includes analyzing what is being said in the industry about the relevant use cases and the techniques that can be used to justify deployment. It also includes reviewing product announcements; the announcement of enabling technologies that are either new or have evolved; the results of plugfests that are intended to test the interoperability of SDN solutions; and the work of organizations such as the Open DayLight consortium.

Much of the education discussed in the preceding paragraph can be accomplished by reading articles and white papers and by attending seminars and workshops. *GottaChange* should also consider downloading some of the open source products that are readily available and playing with those solutions to gain deeper insight into their capabilities and weaknesses. In addition, by yearend 2013 the author will publish a mock RFI for SDN solutions that will be hosted at the author's web site (www.ashtonmetzler.com). *GottaChange* can use this document to structure a dialogue with selected vendors.

Evaluate Professional Services

Given that SDN is a new way of implementing networking, *GottaChange* may choose to use a professional services organization to help with one or more stages in the overall Plan, Design, Implement and Operations (PDIO) lifecycle. The relevant services that *GottaChange* might use could be technology centric (e.g., developing SDN designs, testing SDN solutions), organization centric (e.g., evaluating the skills of the current organization, identifying the skills that are needed and creating a way to develop those skills) or process centric; e.g., evaluating the current processes and developing new ones. These services could be light-weight (i.e., the professional services organization provides limited support) or heavy-weight. They may also be consumed just as part of an initial rollout of NV and/or SDN or they could be consumed over an extended period of time as The Company extends its deployment of NV and/or SDN.

If *GottaChange* is considering leveraging professional services from a third party, then as part of the overall evaluation process, *GottaChange* needs to evaluate the professional services that are provided, both by the potential providers of the NV and/or SDN solution as well as from independent providers of professional services.

Eliminate Organizational Resistance

Organizations tend to resist change and typically the amount of resistance is directly proportional to the extent of the change. Hence, if *GottaChange* is looking at a narrowly defined SDN solution, such as one that implements a network tap application, it can expect minimum organizational resistance. Conversely, if *GottaChange* is looking at a broadly defined SDN solution, then it must anticipate significant organizational resistance.

Organizations are particularly resistant to change if that change is likely to have a significant impact on jobs. Both NV and SDN have the potential to impact the jobs of network professionals. For example, the deployment of NV and/or SDN is likely to reduce the amount of manual labor that *GottaChange* has to perform and is likely to increase the amount of programming that *GottaChange* chooses to perform. As part of planning for NV and/or SDN, *GottaChange* needs to anticipate resistance from the network organization and respond accordingly. For example, *GottaChange* may sponsor members of its network organization achieving some of the new certifications that various NV and/or SDN vendors have recently announced.

However, a number of other factors are also impacting the jobs of IT professionals. This includes mobility, the virtualization of servers and desktops, the convergence of technologies (i.e. networks, servers, compute) and the broad and growing adoption of varying forms of cloud computing. As a result, *GottaChange's* VN and/or SDN initiatives may be just one more factor contributing to the need for *GottaChange's* IT organization to take a broad look at the skills it will need on a going forward basis and to implement a plan to develop those skills. As previously noted, *GottaChange* has the option of leveraging a professional services provider to perform a skills assessment of *GottaChange*'s IT organization.

Perform a POC

Assuming that the previous steps in their plan have produced positive results, *GottaChange* may well elect to perform a POC. The breadth of the POC is directly related to how *GottaChange* has scoped the proposed NV and/or SDN solution and the length of the POC is directly related to the criticality of the tasks that the solution is intended to support.

One goal of a POC is to determine if indeed the proposed solution works and if so, how well it performs. Another goal is to quantify the previously defined key metrics that are associated with each opportunity that *GottaChange* is hoping to address.

Obtain Management Buy-In

GottaChange's network organization needs varying levels of management buy-in at the various stages of their NV and/or SDN plan. For example, little if any management buy-in is needed just for members of *GottaChange's* network organization to attend a seminar or workshop and in many cases, little buy-in is needed in order for them to download open source solutions and to spend a modest amount of time coming to understand the functionality and the limitations of those solutions. Increasing levels of management buy-in are typically needed to engage vendors in detailed discussions of NV and/or SDN, to conduct a POC or to implement an NV or SDN solution.

GottaChange is more likely to get management buy-in if the members of the project team that is evaluating NV and/or SDN anticipate management's concerns and work to resolve those concerns over the entire planning cycle. For example, like virtually all organizations, *GottaChange* will likely face management resistance to implementing any technology or new way of delivering technology if the associated security and compliance concerns are not thoroughly addressed. In addition, *GottaChange* will likely face management resistance if any of *GottaChange's* key processes are impacted.

Like virtually all IT organizations, *GottaChange* will need to develop some form of business case to justify implementing NV and/or SDN. There are three primary components to the business case that *GottaChange* has to develop. One component is the identification and quantification of the benefits that will occur if *GottaChange* implements the proposed NV and/or SDN solution. As noted, one of the primary reasons for performing a POC is to quantify those benefits. Another component of the business case is a multi-year financial analysis that details all of the costs as well as the benefits that are associated with implementing the proposed solution. The third component of the business case is an analysis of what *GottaChange's* IT organization will do to mitigate the risk that is associated with implementing the proposed solution. In addition to mitigating the risk associated with the solution not performing well, this includes mitigating the

previously mentioned concerns that management has about issues such as security, compliance and existing processes.

Summary and Conclusions

There is no doubt that over the next few years that NV and SDN will have a significant impact both on enterprise networks and on the role of network professionals. Because of that, IT organizations and IT professionals need to develop a plan to evaluate and potentially implement NV and/or SDN.

Given the embryonic and rapidly changing nature of NV and SDN, any implementation plan will likely evolve over time. The process that a company such as *GottaChange* should take to evaluate solutions and possibly implement one or more solutions should include most if not all of the following steps:

1. Define NV and SDN
2. Identify the Primary Opportunities
3. Identify the Key Metrics
4. Define the Scope of Possible Solutions
5. Evaluate NV and/or SDN Solutions
6. Test and Certify Solutions
7. Integrate with the Existing Environment
8. Educate the Organization
9. Evaluate Professional Services
10. Eliminate Organizational Resistance
11. Perform a POC
12. Obtain Management Buy-In

Customer Driven Innovation

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The Application Fluent Data Center Fabric

Introduction

The rise of virtualization and cloud computing requires the selection of a best-of-breed data center switching solution as part of an enterprise's overall data center strategy. And at the heart of this strategy is the need to deliver a high quality user experience with new virtualized applications, including video, on new devices such as smart phones and tablets. However, the traditional 3-layer networks designed for a client/server communication model cannot meet the requirements of these new applications and devices, nor can it address the new requirements of virtualized servers and desktops.

Application Fluency for the Data Center

Resilient Architecture

- Simplified 10 & 40 GigE network with low latency and ready for 100 GigE
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- Supports definition of virtual data centers
- Ready for storage convergence with lossless Ethernet

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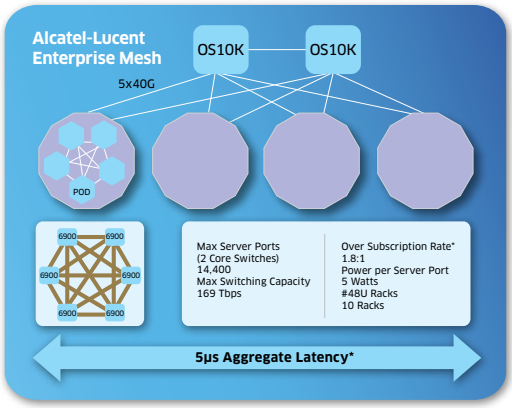
- Application profiles ensure that the network is aware of application provisioning, security and QoS requirements
- The network will automatically sense virtual machine location and movement
- The network will automatically adjust to VM motion within and between data center sites

Streamlined Operations

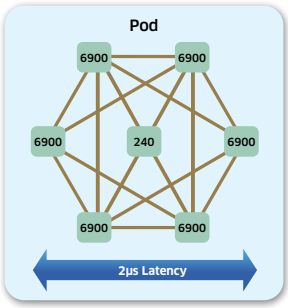
- Applications are automatically provisioned
- Core switches automatically configure top of rack switches
- Converged management for data center network and virtual machine mobility
- Low power consumption

The Alcatel-Lucent Mesh



Alcatel-Lucent provides a unique Application Fluent approach to maximize the benefit from virtualization technologies for servers, the desktop, as well as the network. Alcatel-Lucent's application fluent data center fabric can scale from several hundred to over 14,000 server facing ports while keeping aggregate latency at 5ms, and can automatically adapt to virtual machine movement no matter which server virtualization platform is used.

The Alcatel-Lucent Virtual Network Profile (vNP), embedded in the Alcatel-Lucent Mesh, includes the critical information the fabric needs to understand each application, including provisioning requirements, security profiles, and expected quality of service levels. With this knowledge, the network can manage applications as services, including automatically discovering the location of each virtual machine, modifying the network configuration to follow virtual machine moves and providing an integrated view on visibility on VM movement and current location from a network perspective.



Application fluency in the corporate data center includes its transformation into a multi-site private cloud by extending layer 2 connectivity between data center sites and allowing for seamless delivery of public cloud-based services on the corporate network.

The Alcatel-Lucent Mesh enables enterprises to provide a high quality user experience with mission critical, real-time applications, and to improve agility in deploying new applications while significantly reducing data center costs.

Open Ecosystems and Market Success

Alcatel-Lucent Enterprise is committed to open standards, allowing enterprises to select best-of-breed suppliers for their complete data center solution: servers, storage, data center fabric, and data center interconnect.

- Winner: Best of Interop 2011 for Data Center Switching and Storage
- Data center ecosystem partners include Emulex, NetApp, VMware, Citrix, and QLogic
- Participant in IEEE sponsored Shortest Path Bridging interoperability test with Avaya, Huawei, Solana and Spirent
- Over 20 million Ethernet ports shipped

For More Information

Alcatel-Lucent Data Center Switching Solution
Alcatel-Lucent Application Fluent Networks
Alcatel-Lucent Enterprise

**Assuming Server to Server Traffic 70% within a Pod, 20% between Pods and 10% Via Core*

Alcatel·Lucent
Enterprise

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Agile, Automated Cloud Services

Avaya's Software-Defined Data Center (SDDC) framework offers a simple five-step process for deploying cloud-based services in a matter of minutes. This framework breaks-down the frustration, complexity, and lack of agility that's typically been the norm when building and deploying business applications. Avaya replaces the complicated, independent provisioning steps between the compute, storage, and networking teams with our simplified, orchestrated, and automated workflow. With the SDDC, compute, storage, and network components are automatically combined, customized, and commissioned through a common orchestration layer.

The Avaya SDDC framework is based on the following components:

- **Avaya Fabric Connect technology** as the virtual backbone to interconnect resource pools within and between Data Centers with increased flexibility and scale
- **An Avaya OpenStack Horizon-based Management Platform**, delivering orchestration for compute (Nova), storage (Cinder/Swift) and Avaya Fabric Connect networking (Neutron)
- **Open APIs into Avaya Fabric Connect** for ease of integration, customization and interoperability with other SDN architectures

Traditional methods of configuring network, storage, and virtualized servers could take months and involve several complicated independent steps. Avaya's SDDC framework leverages OpenStack, an open-source cloud operating system. Now Data Center administrations can spin up virtual machines, assign storage, and configure networks through a single GUI. OpenStack provides a control layer that sits above all the virtualized resources within the Data Center, allowing these to be orchestrated – as a single service entity – through a set of common interfaces and a common dashboard.

Avaya Fabric Connect enhances and complements the OpenStack environment by removing the restrictions of traditional Ethernet Virtual LAN/Spanning Tree-based networks. Fabric Connect turns a complex, rigid, and un-scalable model of building network services into a dynamic, flexible, and scalable one. It facilitates the unrestricted movement of virtual machines inside the OpenStack orchestration environment, within and between Data Centers. It also enables the interconnection of old and new resources across the service chain with greater speed and agility.

In summary, with a combination of its Fabric Connect and intelligent orchestration software, based on OpenStack, Avaya is enabling simple and agile **automated** service delivery for applications and users across any combination of physical and virtual components in an evolutionary manner.

Learn more at avaya.com/sdn

Advantages of the Avaya Software-Defined Data Center Architecture

- **Reduced Time-to-Service**: Cloud services enabled in minutes, in a few simple steps.
- **Simplified Virtual Machine Mobility**: End-point provisioning to enable Virtual Machine mobility within and between geographically dispersed Data Centers.
- **Multi-Vendor Orchestration**: Coordinated allocation of compute, storage, and networking resources via a single interface to streamline the deployment of applications.
- **Openness**: APIs ease integration and customization with Fabric Connect, and interoperability with other Software-Defined Networking architectures.
- **Scale-Out Connectivity**: Services scale to more than 16 million unique services, up from the four thousand limitation of traditional Ethernet networks.
- **Improved Network Flexibility**: Overcomes the current Virtual LAN challenges to deliver a load-balanced, loop-free network where any logical topology can be built with simple end-point provisioning.

Top 10 things you **need to know** about Avaya Fabric Connect

(An enhanced implementation of Shortest Path Bridging)

A completely new way to build networks, Avaya Fabric Connect delivers a simplified, agile and resilient infrastructure that makes network configuration and deployment of new services faster and easier. A standards-based network virtualization technology based on an enhanced implementation of IEEE 802.1aq Shortest Path Bridging and IETF RFC 6329, Avaya Fabric Connect combines decades of experience with Ethernet and Intermediate System-to-Intermediate System (IS-IS) to deliver a next-generation technology that combines the best of Ethernet with the best of IP. Avaya Fabric Connect creates a multi-path Ethernet network that leverages IS-IS routing to build a topology between nodes dynamically. Traffic always takes the shortest path from source to destination, increasing performance and efficiency.

Avaya Fabric Connect is an industry unique solution that offers a number of characteristics that set it apart from competing offers. The following Top 10 list below will give you a sneak peek of the advantages Fabric Connect offers:

1 It is more than just a Spanning Tree Replacement

Avaya's dynamic, real-time, service-based Fabric Connect technology is one of the most advanced network virtualization solution on the market today. Going beyond simple L2 multi-pathing capabilities, Avaya Fabric Connect delivers the full breadth of desired integrated services including Layer 2 virtualized services, Layer 3 virtualized services (with multiple Virtual Routing and Forwarding instances), and fully optimized routing and multicast services.

As a result, Fabric Connect enables businesses to gradually migrate away from a host of legacy overlay technologies (such as STP, OSPF, RIP, BGP and PIM) and to enable all services with a single technology – delivering unprecedented levels of network simplification.

2 It's for more than just the Data Center

While many network virtualization technologies are designed exclusively as Data Center technologies, Avaya Fabric Connect extends network-wide, providing a single service end-to-end delivery model. With Fabric Connect you can extend the power of virtualization into the campus and into geographically dispersed branch offices. Services can then easily be deployed via simple end-point provisioning where servers attach and where users attach, thereby increasing speed and agility.

3 It accelerates time-to-service through edge-only provisioning

Fabric Connect allows new services or changes to services to be implemented at the edge of the network – eliminating error-prone and time-consuming network wide configuration practices. Now, add new services or make changes to existing services in days rather than weeks or months. Fabric Connect also offers new levels of flexibility in network design. It allows any logical topology to be built, whether it is Layer 2, Layer 3, or a combination of the two – anywhere where there is Ethernet connectivity. Eliminate design constraints and have the freedom to build services wherever and whenever needed on demand.

4 It offers inherent Data Center Interconnect capabilities

Customers are demanding network virtualization solutions that are not confined to the four walls of the Data Center. Avaya Fabric Connect offers a single end-to-end service construct that can extend between multiple geographically dispersed Data Centers without requiring any overlay protocols or complex protocol stitching. This allows for resource sharing, seamless VM mobility and true active, active connectivity between Data Centers and any other Ethernet-connected enterprise location.

5 It delivers PIM-free IP Multicast that is scalable, resilient and easy to manage

IP Multicast is making a come-back. Many technologies such as next-generation video surveillance, IPTV, digital signage, desktop imaging, financial applications and some network overlays are reliant on Multicast protocols. Avaya Fabric Connect offers a scalable, reliable and efficient way of supporting IP Multicast Routing, without the onerous requirement of configuring, deploying, and maintaining a complex PIM overlay.

Imagine a Multicast network without RPF checks, rendezvous points and complex configuration. Enable Multicast at the edge of the network only, while offering increased scale and performance of the multicast applications. Eliminate your PIM induced headaches forever!

6 It offers inherent multi-tenant capabilities

Avaya Fabric Connect offers integrated Virtual Routing and Forwarding Instances. This allows for private IP networks to be set up quickly and easily across the fabric-enabled network without requiring any overlay protocols. These IP networks can reflect anything from different departments or entities in a traditional multi-tenant environment to separating different types of users (wireless guests, executive access) and even isolating traffic types for security and/or regulatory compliance (i.e. banking transactions for PCI DSS compliance, medical imaging devices in a hospital). The best part is rather than complex configuration, these isolated networks can be deployed quickly and easy at the network edges with just a couple of lines of configuration.

7 It offers "lightening fast" recovergence times (sub-second)

The elimination of overlay protocols has a profound impact on the ability for the network to reconverge. Avaya Fabric Connect customers are experiencing recovery times of less than 50 milliseconds - network-wide - for core, link, or node failures. This represents a vast improvement over large OSPF routed cores and massive improvement when compared to average recovery times in PIM-based Multicast networks.

8 It scales to 16 million unique services

Many network virtualization technologies are based on VLAN virtualization which limits them to the 4096 ceiling. Avaya Fabric Connect, based on the Shortest Path Bridging standard, utilizes a 24-bit header allowing it to scale up to 16 million unique services.

9 It offers proven interoperability with other vendors SPB implementations

Avaya is committed to delivering an open and interoperable solution to market. We have been actively participating with other vendors to demonstrate Shortest Path Bridging interoperability through a series of public tests. The most recent interoperability test was conducted at Interop 2013 in Las Vegas with major industry vendors Alcatel Lucent, HP, and Spirent.

10 It is an important foundation to your SDN strategy

When it comes to SDN, Avaya's strategy is to first eliminate network complexity in order to provide a simple and flexible network foundation. Rather than adding overlays or additional protocols, and creating even more complexity than what we have today, Fabric Connect first streamlines the network then automates it though OpenStack-based orchestration functionality (via a Neutron plug-in). It provides a simplified and proven way to automate the service delivery process and evolve to the Software Defined Network of the future.

Learn more about Avaya Fabric Connect:

Avaya Fabric Connect - video on YouTube, Considerations for turning your network into a Fabric - Packet Pushers podcast, Network Virtualization Using Shortest Path Bridging and IP/SPB – White Paper

SOFTWARE-DEFINED NETWORKING

Software-Defined Networking (SDN) is a transformative network architecture that is reshaping the telecommunications landscape. SDN offers network operators the opportunity to better **monetize** and **optimize** their networks, simplify and automate network operations to reduce OPEX, improve agility to rapidly introduce and differentiate new service offerings to prevail in the increasingly competitive landscape.

Figure 1 depicts the SDN architecture, which is characterized by:

- **Programmability –** Enable unprecedented network control
- **Centralized Intelligence –** Logically centralize network state to optimize resources and construct end-to-end services under granular policy control
- **Abstraction –** Decouple business applications from the underlying network infrastructure, while allowing intelligent software to operate across multiple hardware platforms
- **Openness –** Standard interfaces (including OpenFlow™) achieve multi-vendor interoperability and software

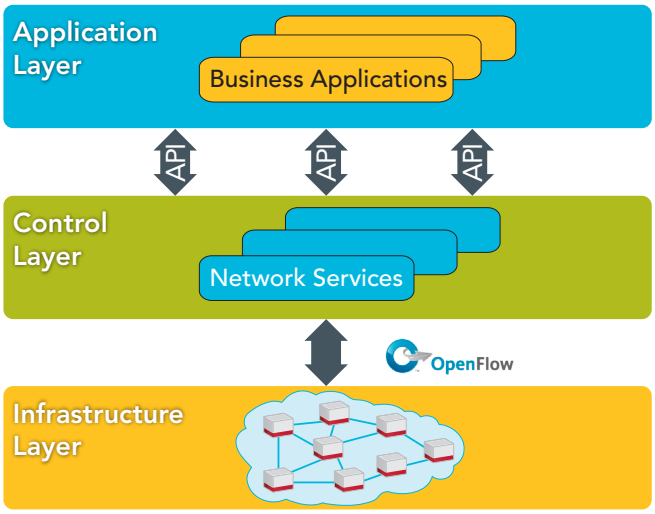

Figure 1. ONF SDN Architecture

Ciena is embracing SDN and leading the charge toward multi-layer, carrier-scale SDN in the Open Networking Foundation (ONF), where Ciena is a founding member and leading contributor. SDN is a key component of Ciena's OPn architecture, which drives down the networking cost curve with converged packet-optical architecture and highly intelligent software functionality.

For more information:

OPn: ciena.com/technology

ONF: opennetworking.org

Ciena's view of SDN emphasizes two key concepts:

- **Autonomic Operations Intelligence –** Streamline operations through automation, resource optimization, and end-to-end service delivery. Grow profit and revenue with real-time analytics: capitalizing on Ciena's experience powering the most intelligent large networks on the globe
- **Expansive Openness –** Embrace open standards and software architectures to enable network operators to innovate and differentiate their businesses

An initial step toward SDN is available today with Ciena's V-WAN Network Services Module, delivering performance on demand to optimize data center interconnection. In concert with our customers and Research & Education partners, we are introducing an ambitious carrier-scale WAN test bed to validate and demonstrate autonomic operations intelligence and expansive openness. Through these efforts—along with our leading role in the ONF, MEF, and related standardization activities—Ciena is shaping the future of multi-layer, carrier-scale SDN.

Learn more at ciena.com/technology/sdn and stay tuned for exciting announcements from Ciena in the months to come!

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ciena : the network specialist

THE FUTURE IS OPn

Cisco Network Virtualization Platform Designed to Automate Application Provisioning and Deployment

Cisco Overlay Approach Focuses on Simplifying and Automating IT Tasks

Network Virtualization (NV) has rapidly emerged as a fundamental enabler for cloud networks and highly virtualized, multi-tenant data centers. NV helps overcome many of the initial obstacles to cloud networking, including addressing network complexity, scalability issues and constraints on workload mobility. But the real promise of NV and SDN leads to orders of magnitude improvements in the automation of IT tasks focused on application deployment, provisioning, optimization and service delivery. The end result will be applications that scale on-demand, vastly improved resource utilization, and much more agile enterprises whose IT organizations respond to changing business requirements in minutes or less.

From Virtual Networks to an Application Centric Infrastructure

The Cisco Nexus 1000V virtual networking platform is a complete overlay/cloud networking solution that includes virtual switching, routing, integrated virtual security services, application delivery services, VXLAN overlay tunneling, network monitoring and analysis, and hybrid cloud integration. Cisco now takes advantage of the simplified, more flexible virtual network by integrating with a range of network automation and orchestration tools running on all major cloud and server platforms, from VMware vCloud Director, to Microsoft System Center, OpenStack and Cisco's own UCS Director.

In June, Cisco augmented its virtual networking and automation capabilities with a new vision for the data center: an Application Centric Infrastructure (ACI). ACI is a cloud and data center fabric designed around application policies that will further simplify and automate the provisioning and deployment of applications, as well as configuring and optimizing the network and network services for application-specific requirements.

The resulting ACI capabilities will further reduce IT costs by automating nearly all application and network provisioning tasks, while allowing IT to be dramatically more responsive to changing business needs by accelerating application deployment, policy changes and fundamentally improving resource allocation and efficiency. The ACI Fabric will be ideally designed for both physical and virtual applications, and also removes obstacles to scale and network visibility that competitive virtual overlay solutions introduce. Nexus 1000V technology and key components of the Cisco virtual network architecture will be part of the ACI fabric.

For More Information

Learn more about the Cisco Nexus 1000V virtual networking portfolio: http://cisco.com/go/1000v

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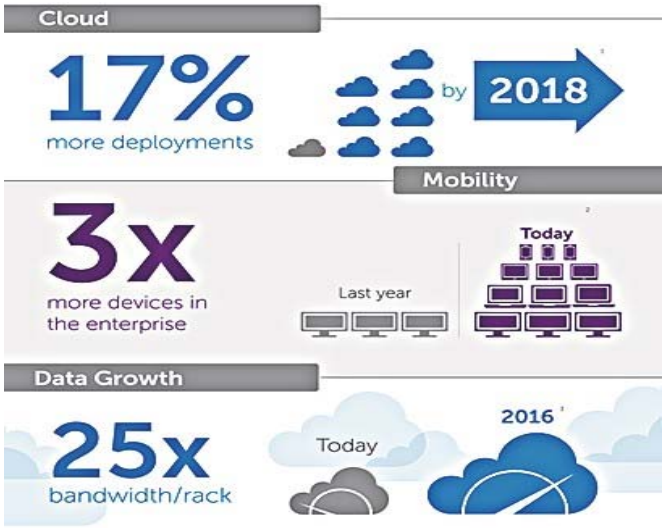
Making **Sense** of **SDN**

and putting it to work for you

The Cloud is here, and things are changing – fast. As the engine of the hyper-connected world, cloud computing has changed the landscape of business , bringing with it a new wave of untapped opportunities. Modern consumers are increasingly drawn to brands that can offer a more savvy and immersive high-tech experience. New technologies can not only offer a deeper understanding of customers than ever before possible, but also promise to refine business operations with an analytical precision that can redefine operational efficiency. While the hyper-connected world can offer tremendous impact, in this new era the opportunities belong to those with the greatest mastery of technology, those who can execute with agility and maximize the impact of the latest innovations.

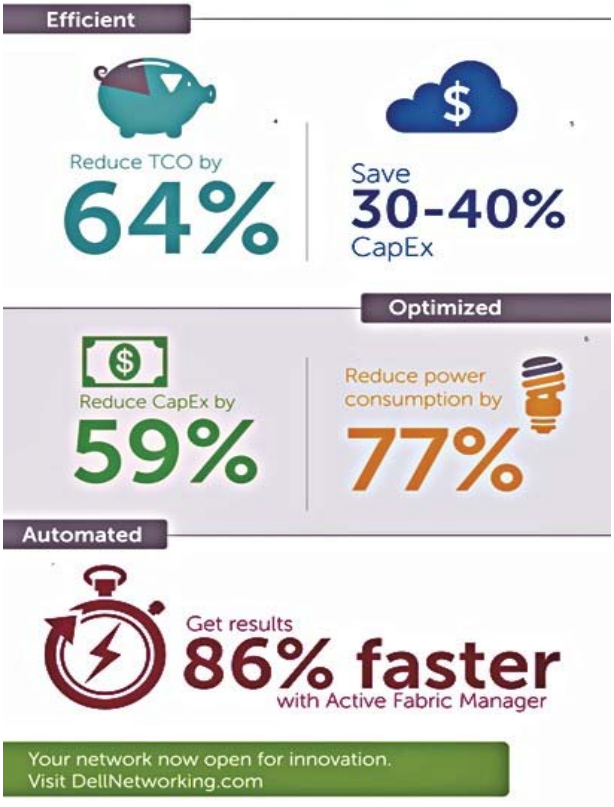


Software Defined Networking is one of the most significant new technologies as it holds the key to the next wave of automation and dynamic integration, igniting business and operational agility while empowering a deeper end-user experience.

At Dell, SDN is not a confusing choice, it is baked into every data center platform we sell. Dell Active Fabric offers a single high-performance architecture that improves the performance of legacy applications while fully preparing enterprises for the rigorous & intelligent demands of next-generation applications. Our robust software suite empowers IT staff to immediately take advantage of SDN, offering out of the box wizard-based design, fully automated deployment and single-pane of glass operations - designed from the ground up to provide a new lifecycle-based approach to highly-automated operations that can redefine enterprise IT.

As the world's largest startup, Dell is embracing the latest innovations and invite you to join in – our staff of experts is waiting to show you how to put SDN to work for you and realize its benefits, today.

Visit **DellNetworking.com** to learn more about Dell SDN solutions or to contact a Dell Representative



Software-Defined Networking

Are your management tools prepared?

Software-Defined Networking (SDN) and Network Virtualization (NV) are quickly becoming priorities because of the promise to dynamically manage traffic loads while lowering costs in response to changing business requirements…

Are you prepared for this evolution?

EMC understands these challenges. Designed to manage physical, virtual and cloud environments, the EMC Service Assurance Suite helps IT operations teams manage infrastructure across each phase of this evolution.

Empower your IT operations team to visualize, analyze, and optimize your service-delivery infrastructure. Learn more at www.emc.com/sa.

To learn more about how EMC products, services, and solutions can help solve your business and IT challenges, email us at asd@emc.com or call 866-438-3622.

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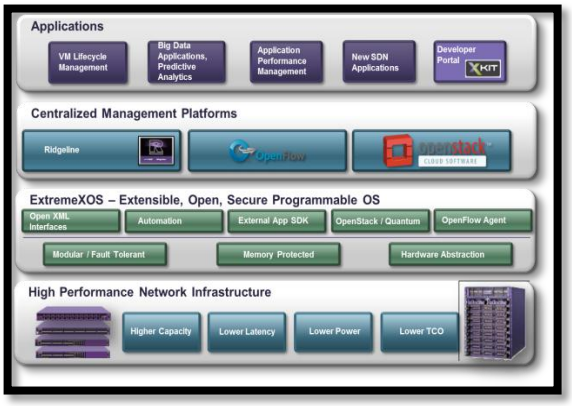
Extreme Networks Open Fabric as the Foundation for SDN

The Extreme Networks ***Open Fabric*** framework includes the key attributes of the data center network, such as high speed, low latency switching, lossless connectivity, multiple paths for resiliency, low power use, automation capabilities, and open standards that are also important to the campus, enterprise and other mission critical networks that require high performance, high scale and resiliency.

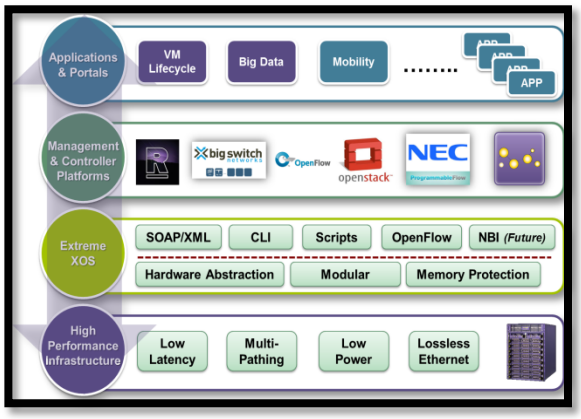
Figure 1 Extreme Networks Open Fabric



Critically important to the Open Fabric is ExtremeXOS®, the network operating system that delivers the consistent set of features across all platforms while ensuring the security and performance of the Open Fabric. ExtremeXOS is modular, extensible, and has integrated security, while providing a single linux-based OS from the core of your network all the way down to the edge. In essence, ExtremeXOS is the system wide ***network abstraction*** layer that allows both seamless introduction of new hardware while opening up the network to management platforms and applications.

The Open Fabric and Extremes are the foundation of the Open Fabric SDN framework. The Open Fabric provides the attributes for the high performing infrastructure while ExtremeXOS abstracts the intelligence of the network, uniquely bonding together to create the Open Fabric SDN framework. The ***network abstraction*** of the Open Fabric SDN approach is found at the ExtremeXOS layer and includes SOAP/XML open APIs, the OpenFlow protocol, CLI and scripting, and the operating system itself. Again, note that network abstraction is available on all Extreme Networks platforms, from edge to core, from 1GE to 100GE. The multitude of network abstraction components allows many different methods for applications and management platforms to access network intelligence, including OpenFlow controllers from NEC and Big Switch Networks, and the OpenStack cloud orchestration system for provisioning storage, compute and network elements.

Figure 2 Extreme Networks Open Fabric SDN



The Extreme Networks Open Fabric SDN strategy therefore extends to include technology partners and systems that leverage the network abstraction capabilities provided by ExtremeXOS.

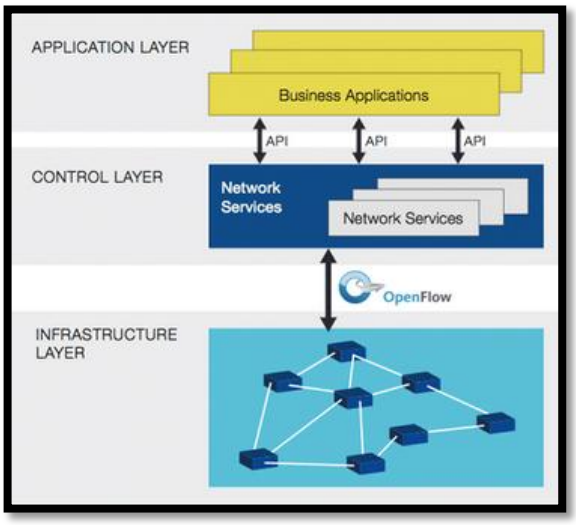
Open Fabric SDN – Inclusive Approach to SDN

From a pure networking standpoint, The Extreme Networks Open Fabric SDN approach includes OpenFlow, Open API's and Network Virtualization as 3 main technology areas inclusive of a broad definition of SDN.

OpenFlow

The OpenFlow protocol is one of the leading new technologies driving the SDN market. OpenFlow is an open standards-based specification led by the Open Networking Foundation.

Figure 3 OpenFlow Protocol



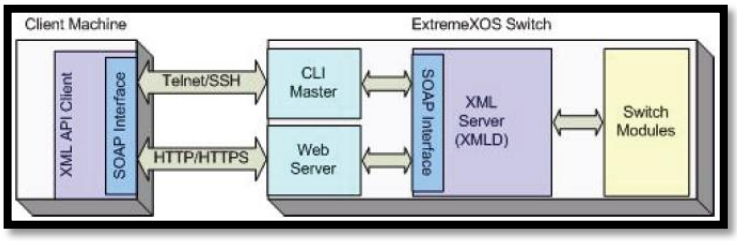
The Open Networking Foundation (ONF) defines OpenFlow: "The physical separation of the network control plane from the forwarding plane, and where a control plane controls several devices."

Open APIs

Using industry standard messaging protocols allow client and server systems to exchange configuration, statistics and state information. OpenStack is a cloud management and orchestration system that uses API's to provision and manage storage, compute and network resources. Extreme Networks has created a software plugin that allows the OpenStack platform to access the network abstraction layer using open API's (SOAP/XML).

As an example, the XML server (XMLD) shown in Figure 4 is responsible for providing a gateway between the external interface and the switch modules. It enforces security; wraps, unwraps, and validates messages; and performs the mechanical translations of results from the modules to the client machine. The XML APIs use the SOAP protocol over telnet/SSH or HTTP/HTTPS to exchange XML configuration messages between the client machine and the ExtremeXOS switch modules.

Figure 4 Extreme Networks Open APIs



"Open API's enable applications and management systems to directly access the network abstraction layer to manage the control, data and management planes of the infrastructure."

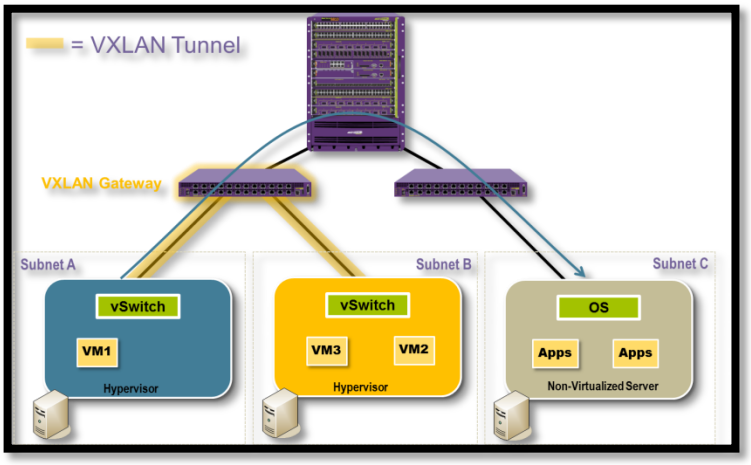
Network Virtualization

Network Virtualization Overlays, commonly called Network Virtualization (NV) or just Overlays, includes a virtual logical network construct over a physical topology. Overlays still require a high performing, robust physical infrastructure and can be leveraged at various networking layers, including:

- Network Virtualization at Layer 2 with VLANs and MPLS
- Network Virtualization at Layer 3 with MPLS VRF's and Virtual Routers (VR) as well as VXLAN and NVGRE for the transport of Layer 2 protocols.

Also, using Open API's and OpenFlow can enable custom applications to create an overlay as well.

Figure 5 Network Virtualization Overlay with VXLAN

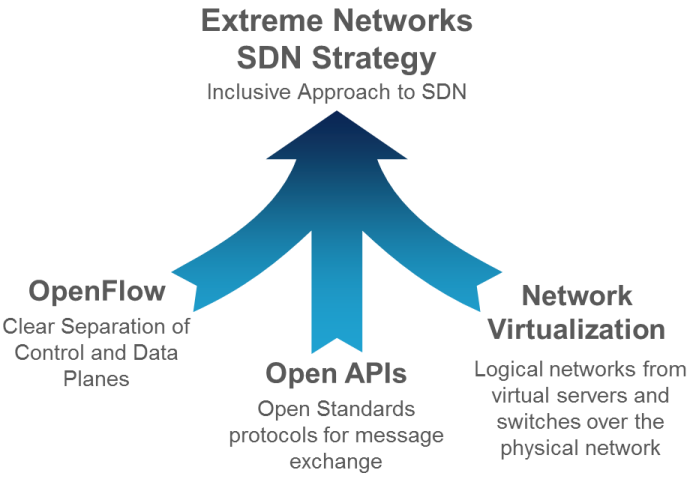


"Network Virtualization Overlays include logical overlays from virtualized server and switching systems that may also include virtualized layer 4-7 services."

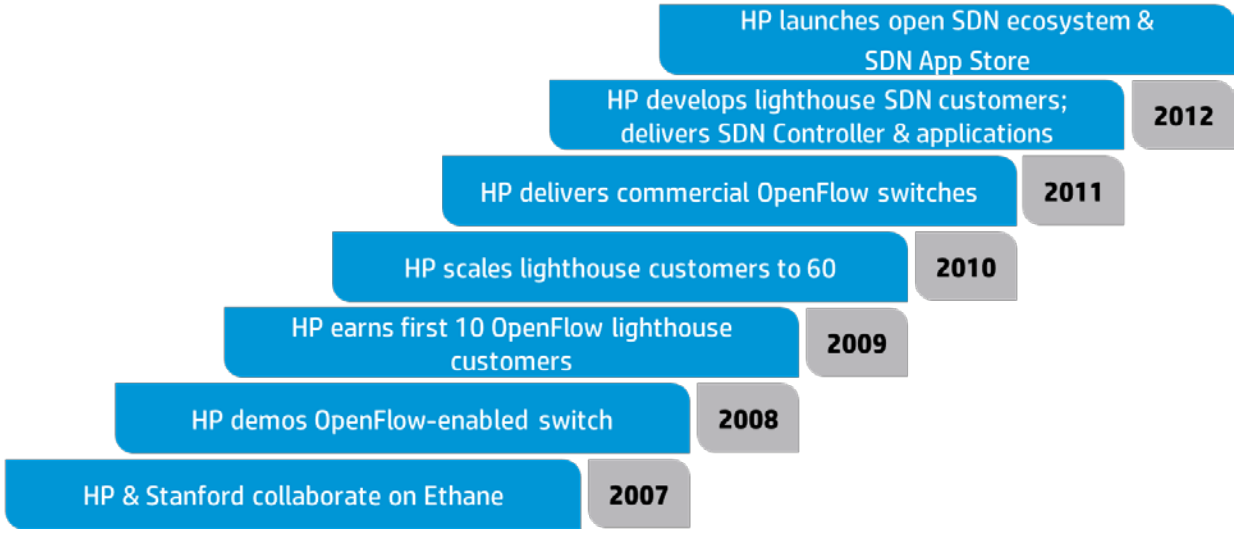
Extreme Networks: The Inclusive Approach to SDN - Summary

This inclusive approach to SDN allows a complementary mix of industry and customer perspectives, enabling multiple different SDN strategies. From OpenFlow to Open APIs to Network Virtualization, the Extreme Networks Open Fabric SDN framework enables an inclusive approach to SDN that leverages the ExtremeXOS network abstraction capabilities of a single binary OS ubiquitous from edge to core.

Figure 6 Inclusive SDN Approach

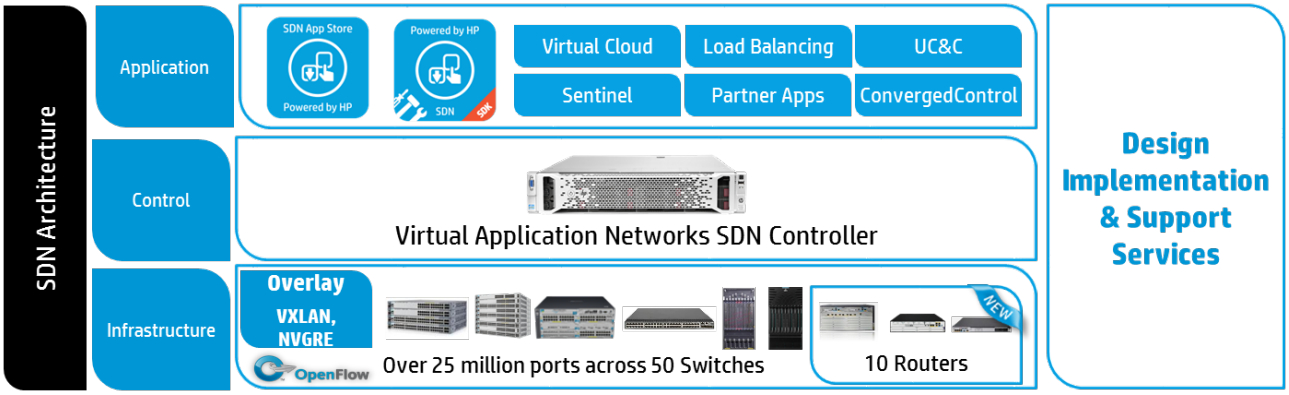


HP is leading Software-defined Networking



HP Open SDN portfolio, SDK, App Store enables Ecosystem

Programmable network aligned to business application delivers agility



ProgrammableFlow

Empowered by Innovation NEC

Kanazawa University Hospital

Reaping the benefits of a successful production SDN deployment

Keisuke Nagase, M.D., Ph.D., is a professor of medicine, healthcare administration, and medical informatics at Kanazawa University in Kanazawa, Japan. He also serves as vice-director in charge of budget/management and director, department of corporate planning for Kanazawa University Hospital. The hospital recently began overhauling its cumbersome network infrastructure by deploying NEC's ProgrammableFlow® solutions, a network solution based on OpenFlow technology. With 839 beds and 33 clinical departments, Kanazawa University Hospital is one of the largest and oldest teaching and research hospitals in the country.

金沢大学 KANAZAWA UNIVERSITY

Interview excerpt from www.SDNcentral.com

What kind of IT environment do you have at the hospital? What is the rough annual IT spend?

Our network is essential to the day-to-day business of providing patient care. From electronic medical records to medical equipment, IT is critical for everything in the hospital. The patient management system and billing system are the largest in scale in terms of IT, but everything is connected – ICU, operating rooms, medical equipment. We spend roughly $600M Yen ($6M-$7M USD) per year on IT.

What are the major IT problems you have had to solve at the hospital?

As an educational hospital, we are large and armed with innovative new healthcare technologies. The problem is, many computer networks have been deployed independently because each medical equipment manufacturer and vendor wanted to simplify the environment around their equipment.

When I moved to this hospital from a previous position, I faced a chaotic situation. Information technology is not our core business, patient care is. As a result, human resources for information system management were limited for a long time. The existing network was high risk and high cost, and poor control over the network led to many unfavorable incidents and accidents. For example, packet storms caused by large-scale loops would interrupt daily jobs for four hours.

Even daily operations were challenging. Technologies evolve rapidly in the medical field, and doctors often try new equipment. Connecting this equipment to the network involved changing settings and verifying connections, and sometimes even rewiring, putting a considerable strain on the hospital's budget. A network that requires setting changes and rewiring every time a new piece of equipment is connected cannot be called stable. The other issue is slow reconfiguration of the network due to the processes in place, adding a new piece of equipment could take 3 months including time to initiate the contract for the add/move/change.

Why did you decide to use OpenFlow technology to address these problems?

We were looking for a more agile solution that had the same or lower risk as our existing network, at the same or lower cost. That was OpenFlow. We did not select SDN as a result of passion for a new technology. Our business is not IT -- our system is directly related to the life or death of our patients. Education, research and healthcare are our business.

There was no breakthrough or epoch-making technologies in SDN, we believe, but rather an innovation of philosophy. We wanted to be free from any specific manufacturer. We selected OpenFlow because we need it. We consider OpenFlow switches and controllers to be stable.

"We did not select SDN as a result of passion for a new technology. Our business is not IT—our system is directly related to the life or death of our patients."

"Now we are enjoying rapid recovery time and flexibility in a network with reduced maintenance and operational costs. The time for recovery was reduced to seconds rather than minutes."

As you know, many manufacturers are modifying their existing products to be OpenFlow enabled. With such consideration, we felt the stability of OpenFlow switches and controllers to be the same or better than conventional switches, even at their worst. Because the software is simple, it is essentially more stable than our legacy technology. The only exception is if an incompetent person codes the applications running on the controller.

How did you introduce OpenFlow to the existing system?

We added a new general research building to our campus more than one year ago. Each clinical department and its corresponding university department moved to the new building. In the new building, four independent networks were requested to be deployed, and the existing network also needed to be deployed to the new building. We introduced SDN/OpenFlow in the new building to eliminate complexity of network.

We thought the deployment of SDN to the new building was quite a good opportunity to evaluate SDN. Multiple in-house LANs are required to implement SDN, making the situation a good test case for network slicing with SDN. By adopting SDN in the new building, we also decided it would be a good test for migration from our legacy network to SDN.

Even if the SDN network failed somehow, the effect would be limited because the new building is connected to the old hospital building and legacy network via a corridorwe ran a parallel network initially that the staff could still access in different rooms but only a short walk away. We concluded adopting SDN/OpenFlow in the new building would at worst be the same risk, same cost.

We integrated the existing independent network using SDN/OpenFlow in the new research building. With OpenFlow, the network within the building was kept simple, and our new virtual tenant networks are merged with the existing hospital network using link aggregation.

"…the operational expenses and maintenance cost has reduced markedly. I estimate a savings of 80% on my operational expenses."

Why did you choose NEC ProgrammableFlow switches and controllers?

An NEC network Systems Engineer (SE) understood the deeply unstable situation of our network, and he suggested we use OpenFlow. NEC was the only supplier of production quality OpenFlow switches at the time of our contract, and they have been our partner for many years. The NEC SE built a good relationship with the assistant professor in charge of the hospital information system.

NEC installed two ProgrammableFlow controllers and 16 switches in our new building. It allowed us to install devices one floor at a time and expand gradually and safely. We could manage each department's LAN without impacting our existing network.

With NEC's ProgrammableFlow solution, the entire network is managed like a large virtual switch, making an independent virtual network. Our OpenFlow switch was implemented as edge (floor) switches. We have full mesh wiring between switches. In the center, the OpenFlow network is connected under the existing L3 switch (core switch) using link aggregation, so as to be configured as single L2 switch network from L3 switch.

For redundancy, we have two sets of OpenFlow controllers. For OpenFlow switches, we have two sets in center side, two sets in the new building side, and two sets on each floor, for a total of 16 sets. We also have two sets of secure channel switches—in the system operation center and the new building. NEC required only one month to get the new network up and running.

How does the SDN network compare in cost and price?

The acquisition cost of the hardware was almost the same as the legacy network. However, the operational expenses and maintenance cost has reduced markedly. I estimate a savings of 80% on my operational expenses, including reduction in staff hours required to manage the network. We also expect that the price of OpenFlow switches and OpenFlow controllers will be reduced further as a result of competition in the market. Furthermore, with the flexible configurability of OpenFlow, a full mesh configuration is not required, and our next phase will be in realized in less cost per switch.

"I can now provision the network after new equipment installations or equipment moves in minutes instead of the 3 months it used to take."

What benefits have you seen from deploying SDN?

As I've mentioned, I've seen significantly lower maintenance costs, allowing me to make much better use of my human resources at the hospital. More importantly, I now have the ability to perform moves, adds and changes to my network much faster than before. I can now provision the network after new equipment installations or equipment moves in minutes instead of the 3 months it used to take. This is achieved via ProgrammableFlow, leveraging the OpenFlow protocol, which will automatically connect the equipment to the right network instantly.

So, what's your final evaluation of SDN and NEC's ProgrammableFlow solution?

I would say that the network has been successfully delivering critical patient health records as well as MRI and CT scan data, reliably and efficiently. With this experience we decided to expand our ProgrammableFlow OpenFlow network to the entire hospital network over the next two years. We also expect to refresh and clean up our IP address space from a chaotic situation utilizing flexibility we gained from our SDN network.

In summary, I would declare our SDN deployment highly successful and would recommend other medical centers take a serious look at deploying SDN and reaping the significant benefits today.

"I would declare our SDN deployment highly successful and would recommend other medical centers take a serious look at deploying SDN and reaping the significant benefits today."

Key Features of the NEC ProgrammableFlow Networking Suite:

- **Drag and drop network design**: The GUI interface to the ProgrammableFlow Controller includes the familiar CLI found on most routers and switches today, so with minimal training a network admin can easily point and click to design an entire network from the single pane provided by the ProgrammableFlow Controller. This can radically reduce network programming and design time and errors caused previously by human intervention.
- **VM mobility**: With the ability to readily direct traffic throughout the data center—or throughout multiple data centers, it is possible to better manage all of the resources in a data center. For example, in NEC's own data centers in Japan, where they have recently implemented the ProgrammableFlow Fabric, it has enabled them to spread traffic between East and West Japan, offloading servers in East Japan that were nearing capacity, and postponing purchase of new servers, for a substantial saving. VM Mobility also enabled Nippon Express to complete a data center consolidation move that normally would have taken 2 months down to 10 days.
- **Bandwidth monitoring and traffic flow visualization**: This feature of the ProgrammableFlow Controller provides performance monitoring of network flows and centralized management of network traffic, reducing bottlenecks and enabling smooth, streamlined network operations with substantially improved network admin productivity.
- **Secure, multi-tenant networks**: Secure, multi-tenant networks from the ProgrammableFlow Controller enables customers like Genesis Hosting to expand their service offering with new sources of revenue potential. Genesis also reports software engineering investments were reduced by 100 hours each month with the advancements provided by ProgrammableFlow multi-tenancy.
- **Automation and administration of business policy to network management**: With network services aligned with business policy, automation such as prioritizing classes of applications or specific applications over other enterprise activity during peak loads is now possible with the ProgrammableFlow Network Suite, with multiple paths provided automatically. These capabilities offer significant value, particularly to enterprises engaged in heavy transaction loads.
- **Load balancing**: Traditional networking protocols often lead to performance-reducing bottlenecks. ProgrammableFlow uses path selection algorithms to analyze traffic flow across the network, check all available paths, and customize traffic flows to maintain performance and fully utilize network capacity. This increases the utilization of the network and improves application performance.

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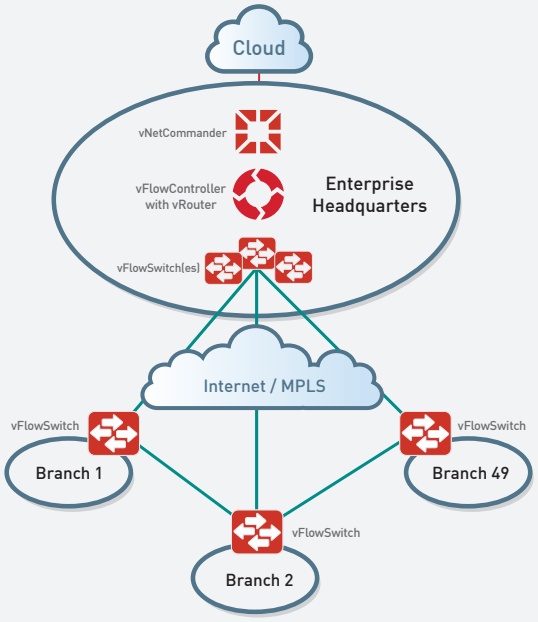
A fully optimized, automated, cost-effective networking solution, Netsocket Virtual Network provides end-to-end virtual networking, unified network management, real-time network service analytics with intelligent network remediation as well as superior interoperability with legacy routed networks.

Virtual network distributed on commodity x86 hardware



NVN significantly reduces lifecycle CAPEX/OPEX beyond that of traditional site-by-site-managed networking solutions. Immediate benefits include CAPEX savings of 3:1 and OPEX savings of 5:1 over single-purpose, hardware-based legacy networking solutions.

Go "Virtual" Networking Today

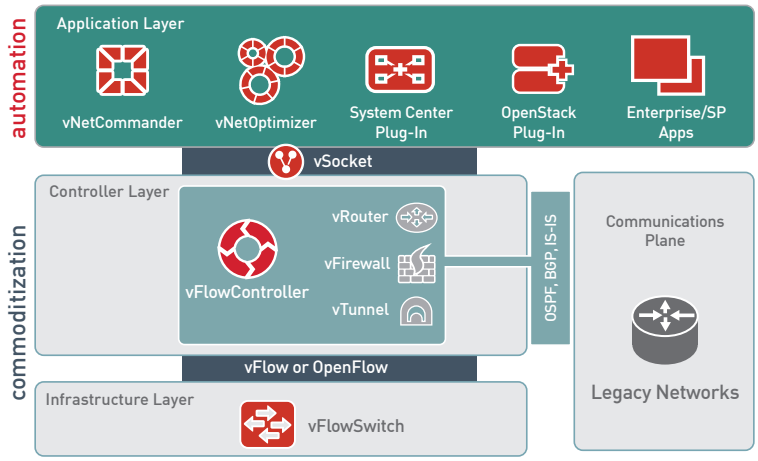
Software-defined Networks (SDN) offer a vision of networks evolving to a virtualized world where the networks of yesterday can live harmoniously with the software-based network elements of tomorrow. This virtualized world of SDN offers service providers and enterprises the promise of doing this in a way that allows users to introduce new features and functionality without disrupting their business along the way. Coupled with the pledge of automating fast deployment of new applications that can be integrated into and layered on top of networks, virtual networks hold the potential to deliver optimum business results and an increased bottom line.

So, how do network innovators bridge the gap between rigidly inflexible and costly 'stone-age' networks and the seemingly futuristic network nirvana that SDN promises?

Netsocket Virtual Network (NVN) delivers on the promise of SDN with a network solution that can address the needs of today's dynamic business applications with a virtualized infrastructure that provides end-to-end visibility and centralized remediation for the entire network, transforming it into an asset that is responsive to the needs of the business.

Netsocket Virtual Network (NVN)

Software Defined Networking (SDN) Three-tier Architecture



Making The Business Case — Netsocket Virtual Network for Distributed Enterprises

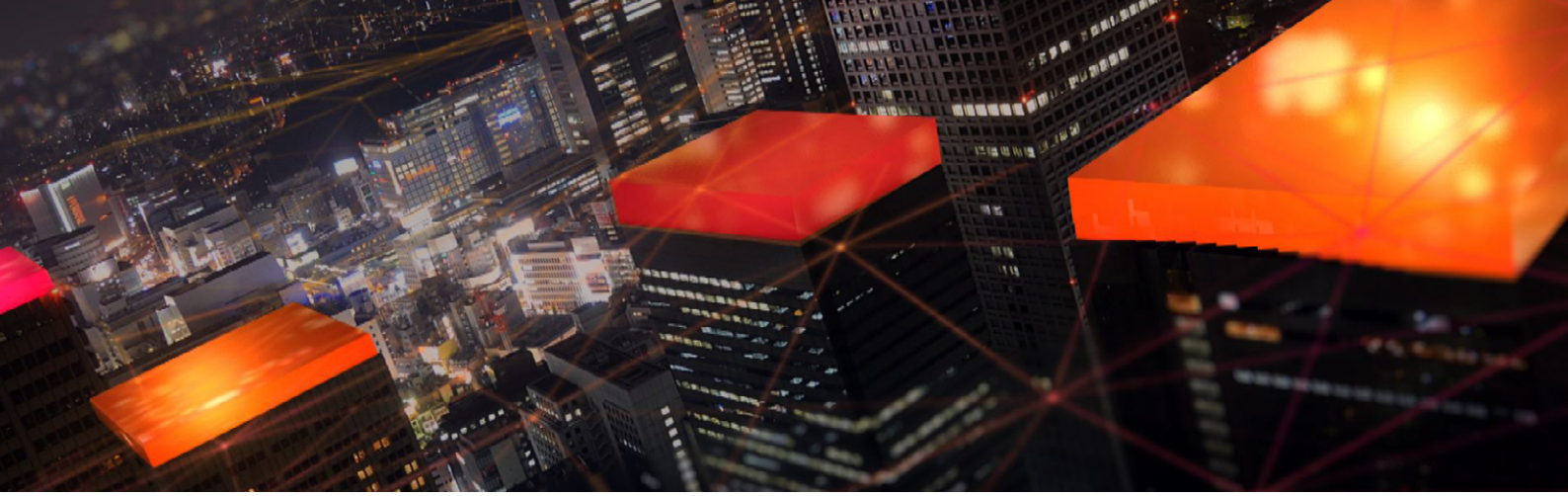
Today's data center centric SDN solutions simply do not address the underserved distributed enterprise use case requirements. They lack necessary functionality such as flexible logical addressing, inter-site quality of service and diverse off-net access per site. Netsocket fills this void with the Netsocket Virtual Network (NVN) delivering a flexible, low-cost, centrally managed virtual network optimized for the enterprise LAN and WAN edge network deployments. Deployed on commodity x86 servers, the Netsocket Virtual Network interconnects enterprise branches in just a few minutes, with no networking expertise required at the site. Its switching and routing components are automatically deployed and provisioned to each branch office using the centralized, intuitive network management application vNetCommander. Utilizing its robust, web-based GUI, the vNetCommander is designed to handle automated deployment, installation, configuration and orchestration of virtualized networks—all from a centralized console.

Netsocket Virtual Network delivers on the promise of SDN through a dramatic reduction in lifecycle costs, impressive network flexibility and deployment response time, and exceptional scalability. NVN provides for legacy network interoperability as well as the ability to easily and cost-effectively incorporate new software or make network changes and updates based on future business needs.

Explore how Netsocket can virtualize your world, visit www.netsocket.com.

Experience your own virtual network today, download the complimentary NVN Early Experience version at www.virtualnetwork.com.

netsocket™



The Consumable Datacenter Network

Taking cloud computing to the next level

The move to cloud computing and storage has changed the way Enterprise users access and consume data. Unfortunately, today's data communications networks aren't keeping pace with this dynamic business environment, and they're struggling to deliver consistent, on-demand connectivity.

That's where we come in. Nuage Networks™ closes the gap between the network and the cloud-based consumption model, creating an infrastructure in which network resources are as readily consumable as compute and storage resources. Our approach enables enterprises to transform the way they build and use their networks, which has a profound effect inside and across multiple datacenters. The transformation is also felt at the critical remote working environment, through a seamless connection to the Enterprise's Wide Area Network.

WOULDN'T IT BE NICE IF...

- Datacenter infrastructures were so simple and standards-based that you could break the vendor lock and work with whichever suppliers offered you the best solutions for your business?
- The network could expand and evolve transparently with the needs of applications, bypassing the datacenter's arbitrary boundaries?
- The datacenter network team could set up controlled, secure templates that application teams could use to deploy applications on the network for and by themselves — without manual transactions or unnecessary project overhead?

Before the move to the cloud, enterprises had to purchase large compute systems to meet the peak processing needs of a limited set of specific events, such as financial milestones (month end or year end), or annual retail events (holiday shopping). Outside of the specific events, the systems were underutilized. This approach was therefore expensive, both in terms of CAPEX and OPEX, requiring significant outlay for power, space and air-conditioning.

Cloud-based datacenters have unshackled the IT environment, making it possible for applications to request additional compute and storage on an as-needed basis. Peak demands can be provisioned "just in time", which lowers operational costs and provides the ability to share compute resources across applications.

The term "cloud" means many things to many people. We focus on two key benefits that cloud computing delivers to Enterprises:

Abstraction of the application from the infrastructure. Cloud computing separates the application from the physical compute and storage infrastructure. This allows workloads to be consistently configured remotely, and templated for mass deployment. End users don't need to worry about the location and specifications of individual hosts. Virtualization and cloud management tools abstract those details to make the infrastructure more readily consumable.

Customer self-fulfillment. Cloud Management Systems (CMS) like Alcatel-Lucent CloudBand™ and the abstraction layer enabled by server virtualization allow IT departments to minimize the tedious and cumbersome processing of application-to-network transactions. For example, IT can provision end customer access policies in the CMS to govern who is authorized to create virtual machine instances, in which location, how many are allowed, and who is the funding department. Users and work groups get instant application deployment, which in turn, makes the business more agile and responsive — critical

attributes in today's enterprise environment. At the same time, operational expenses associated with the handling of work orders is greatly reduced.

As a result of these innovations, Enterprises enjoy a powerful new IT environment in which applications can consume compute resources easily. However as the dynamic nature of cloud computing becomes mainstream, the underlying datacenter network is struggling to match the flexibility of the applications. In fact, most often the network is the weak link, inhibiting the enterprise's ability to profit from the benefits that moving to the cloud should provide.

While virtual compute resources can be instantiated in seconds, it often takes days for network connectivity to be configured and established. Furthermore, the static configurations used by today's networks do not provide the efficiencies and flexibility needed to drive maximum server utilization and application availability.

Consuming the Network

Nuage Networks ensures your network elements are as efficient and flexible as your cloud computing. The result is a choreographed datacenter environment where the compute resources and network work seamlessly.

Imagine the possibilities when network resources are easily consumable. A Nuage Networks datacenter network is as dynamic, automated and virtualized as the server infrastructure, and supports the needs of applications with instantaneous network connectivity.

Nuage Networks eliminates the constraints that have been limiting the datacenter network as it scales out to meet growing demand. With Nuage Networks, you can:

- Define the network service design per application
- Optimize your workload placement across datacenter zones or even across geo-diverse datacenters
- Maximize efficiency of your compute and storage resources

Nuage Networks paves the way for datacenters of the future to be the heartbeat of a powerful cloud infrastructure. Enterprises and user groups could conceive and consume their own secure slices of a robust multi-tenant infrastructure, with appropriate operational visibility and control.

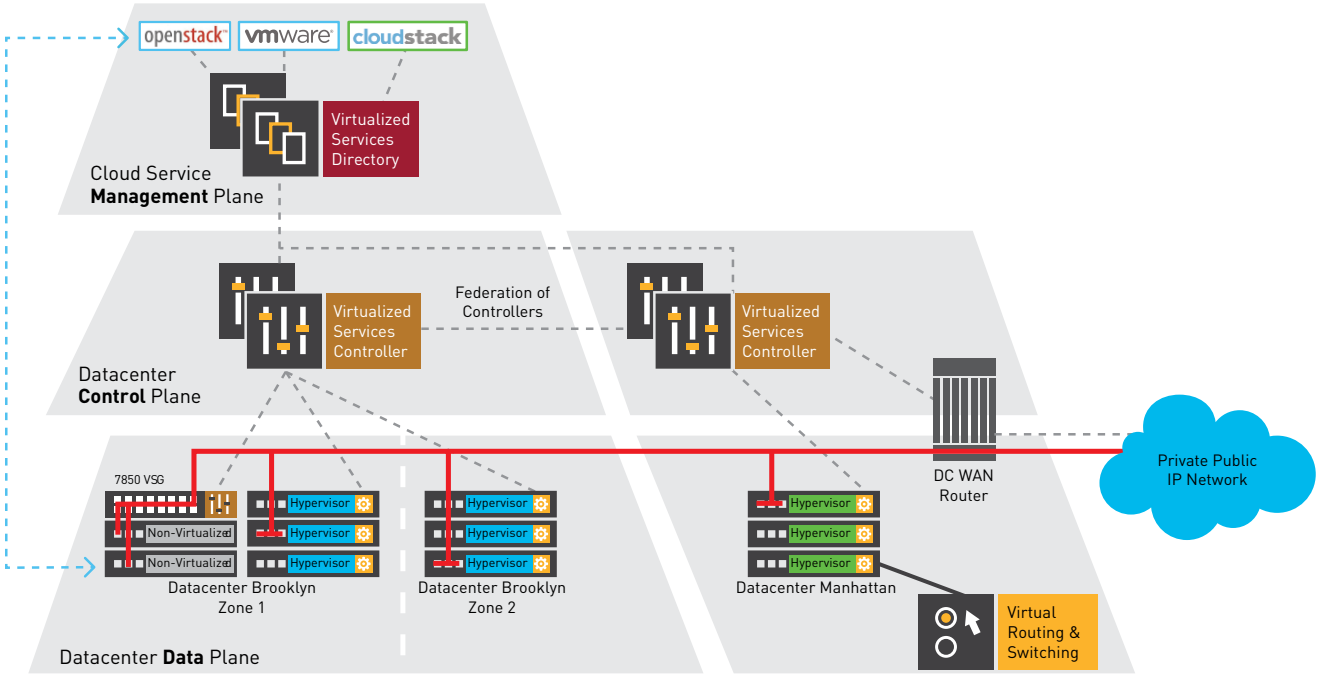
Nuage Networks Virtualized Services Platform

Nuage Networks Virtualized Services Platform (VSP) is the first network virtualization platform that addresses modern datacenter requirements for multi-tenancy, full-featured routing and security at scale. It also integrates seamlessly with wide area business VPN services. It is a software solution that transforms the physical network into a simple to manage, rack-once and wire-once, vendor-independent IP backplane. As a result, network resources within and across datacenters can be treated as an elastic resource pool of capacity that can be consumed and repurposed on demand. Nuage Networks enables unconstrained datacenter networks for the cloud era.

Nuage Networks delivers virtualization and automation of business networks through the three key elements in the Nuage Networks VSP:

Virtualized Services Directory (VSD). Configuration of networks is complex. To eliminate unnecessary complexity while leaving full control and visibility of applications with the IT administrator, the VSD abstracts networking constructs down to their base primitives in four categories: Connectivity Domains, Security, Quality of Service, and Analytics. This allows the requirements for network services to be expressed simply,

FIGURE 1. Nuage Networks Virtualized Services Platform



consistently, and in a repeatable manner. The critical need for mobility is also addressed, ensuring network services adjust gracefully and instantly as application endpoints and workloads move from virtual machines within or across datacenters.

The VSD also provides a rich permission-based multi-tenant interface to enable end user provisioning by application owners. Through its role-based hierarchy of permissions, the VSD eliminates operational delays and minimizes transactions between organizations while providing visibility and control of the network "slices" that each group is given in support of their application requirements.

Virtualized Services Controller (VSC). The VSC is an advanced SDN controller that manages the provisioning of virtual network services by programming the edges of the network using OpenFlow™. The VSC ensures that the network follows the application instantaneously. Parting with cumbersome and error-prone device-by-device manual provisioning, Nuage Networks introduces an event-triggered and pull-based configuration model. Once application events such as moves, adds or changes are detected, appropriate policy-based configurations are instantaneously applied. Leveraging Alcatel-Lucent's proven Service Router Operating System, which has been deployed in over 400 service provider networks worldwide for over a decade, the VSC runs a full and robust IP routing stack that allows it to communicate and seamlessly integrate into existing networks.

Virtual Routing and Switching (VRS) is a true hypervisor for the network. The first of its kind in the industry, the VRS fully virtualizes network offerings ranging from distributed virtual Layer 2, Layer 3 forwarding and Layer 4 security. These virtual network services leverage the existing network infrastructure and are offered in a standards-based manner compliant with IETF NVO3. Operators can use whatever servers, hypervisors, and cloud management systems they choose; the Nuage Networks solution abstracts and automates the cloud-networking infrastructure.

In many real-world installations, datacenter environments are a mix of virtualized and non-virtualized assets. To help all datacenters benefit from automation and network virtualization, Nuage Networks supports the full range of options. Software gateways such as the Nuage VRS-G are ideal for environments with relatively low density of bare metal servers and appliances, just as hardware VTEPs from our ecosystem partners provide a viable alternative for certain use cases and environments. For environments with significant investment in bare metal servers and appliances, a new breed of high performance gateway is needed.

The **Nuage Networks 7850 Virtualized Services Gateway (VSG)** is a high-performance gateway that extends Nuage Networks SDN 2.0 functionality seamlessly between virtualized and non-virtualized assets in the datacenter. Working in concert with the Nuage Networks VSP, policies devised for applications automatically extend across virtualized and non-virtualized assets for a fully automated network infrastructure.

FIGURE 2. Nuage Networks datacenter network benefits

	Status Quo	NUAGE NETWORKS DELIVERS What is Needed
Virtualization of network services	LAYER 2 VIRTUALIZATION	FULL NETWORK VIRTUALIZATION, L2 THROUGH L4
Breadth of application models	SIMPLE SCENARIOS	HYBRID CLOUD SERVICES, SEAMLESS VPN CONNECTIVITY
Availability & scale	FRAGILE, NOT MULTI-TENANT	ROBUST, THOUSANDS OF TENANTS
Reach & mobility of network resources	ISLANDS, WITHIN RACKS OR CLUSTERS	SEAMLESS VIRTUALIZED FABRIC, THROUGHOUT & ACROSS DATACENTERS
Network service turn-up time	SLOW, MANUAL, CONFIGURATION DRIVEN	INSTANTANEOUS, AUTOMATED POLICY-DRIVEN
Openness	SPECIFIC TO VENDOR IMPLEMENTATIONS	INDEPENDENCE FROM HARDWARE CHOICES
Breadth of assets automated	VIRTUALIZED ASSETS, LIMITED OPTIONS FOR NON-VIRTUALIZED	ALL DATACENTER ASSETS, VIRTUALIZED & NON-VIRTUALIZED

NU•ÂHJ: FROM FRENCH, MEANING "CLOUD"

The cloud can be more than what it is. In fact, it needs to be. When we founded Nuage Networks, it was with the idea that it's time for the cloud to come of age. From the beginning we recognized the unique challenges that cloud service providers and large enterprises face delivering and managing large, multi-tenant clouds. While the virtualization of compute and storage has evolved quickly, the network simply has not kept up. The result is that today your cloud is being held back. And so is your business.

When we started Nuage Networks, it was with the mission that we could empower our customers to finally deliver on the true promise of the cloud. We envision a world in which IT and IP are no longer in conflict, but rather work in concert to propel your business and elevate the cloud for every one of your customers. We see a world where innovation isn't hampered by infrastructure, and network resources are as effortlessly consumable as compute and storage.

To make this vision a reality, Nuage Networks brings a unique combination of groundbreaking technologies and unmatched networking expertise. This enables us to create solutions that do more than provide incremental improvement. It allows us to introduce radically new thinking and pick up where others have left off, delivering a massively scalable SDN solution that makes the datacenter network able to respond instantly to demand and boundary-less.

Visit us on the web

Our mission is to help you harness the full value of the cloud.

nuagenetworks

www.nuagenetworks.net

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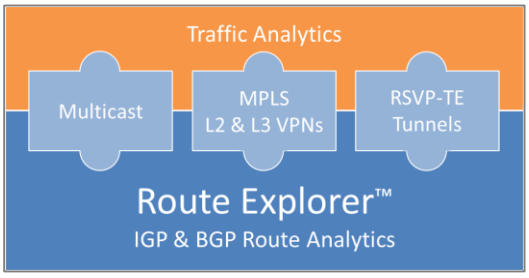
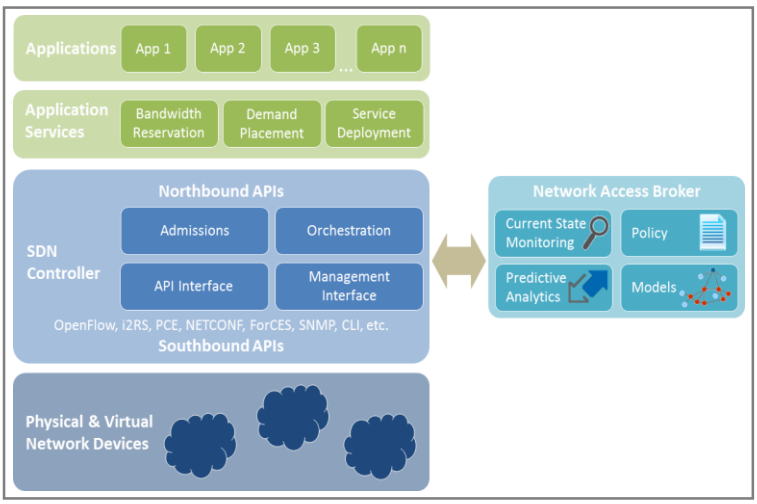
While much of the current industry focus on software defined networking (SDN) is in the context of the software-defined data center, Packet Design is enabling SDN in the routed wide area network (WAN) where network programmability and automation demand best practices and tools for management visibility and policy-based control. Always-current network models and traffic load profiles are required for real-time network provisioning by the SDN controller as well as for the successful monitoring and management of SDN applications, such as bandwidth calendaring and workload placement, as well as virtualized network functions and overlay networks.

Packet Design's Route Explorer™ system, available today, maintains a 100% accurate model of the network topology in real time, including IGP areas, BGP autonomous systems, RSVP-TE tunnels, and Layer 2 and Layer 3 VPNs. This is augmented by the recording and analysis of traffic flows to create traffic load profiles. These network models and traffic matrices are available for a variety of network deployment models, including networks with or without RSVP-TE tunnels. Whether the network is programmed or configured (or a combination), network performance can degrade under a variety of conditions, including link or node failures. Route Explorer compares and contrasts network state to a baseline and identifies the root cause of problems quickly. Its monitoring, diagnostics, modeling and reporting capabilities are directly applicable to SDN deployments, providing real-time monitoring, back-in-time forensic analysis, and network event and demand modeling.



The Route Explorer System

The Packet Design Network Access Broker (NAB), currently in development, uses topology models, traffic profiles and business policies to determine in real time whether or not application requests for network resources can be satisfied. It calculates the impact that requested changes will have on other services by determining the resulting network topology and traffic behavior. The NAB also examines historical traffic profiles to determine if network load is likely to change significantly after the application request is satisfied (for example, the predictable increase in market data and trading traffic that occurs when stock markets open). With Packet Design's unique real-time network models, traffic profiles and analytics, the NAB, which may be integrated in the SDN Controller or exist as an independent software function, provides the intelligence required for mainstream viability of software defined networking in the WAN.



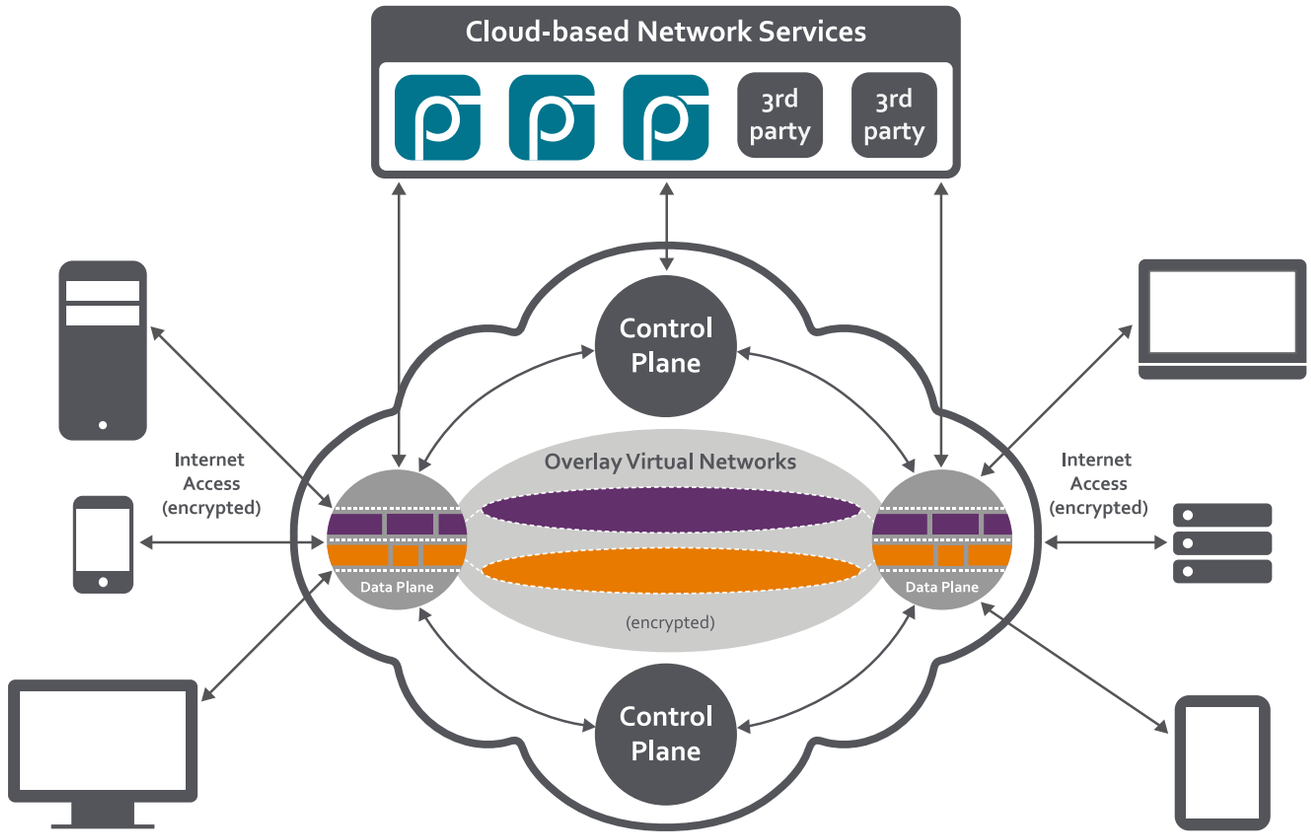
Network Access Broker for SDN

pertino

Cloud Network Engine

Create secure, optimized cloud networks in minutes, add people and devices instantly, and deploy network services on demand.

- Multi-cloud overlay
- Distributed control panel
- L3 switching data plane
- Network service virtualization
- Real-time orchestration
- App store



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OPEN NETWORKING

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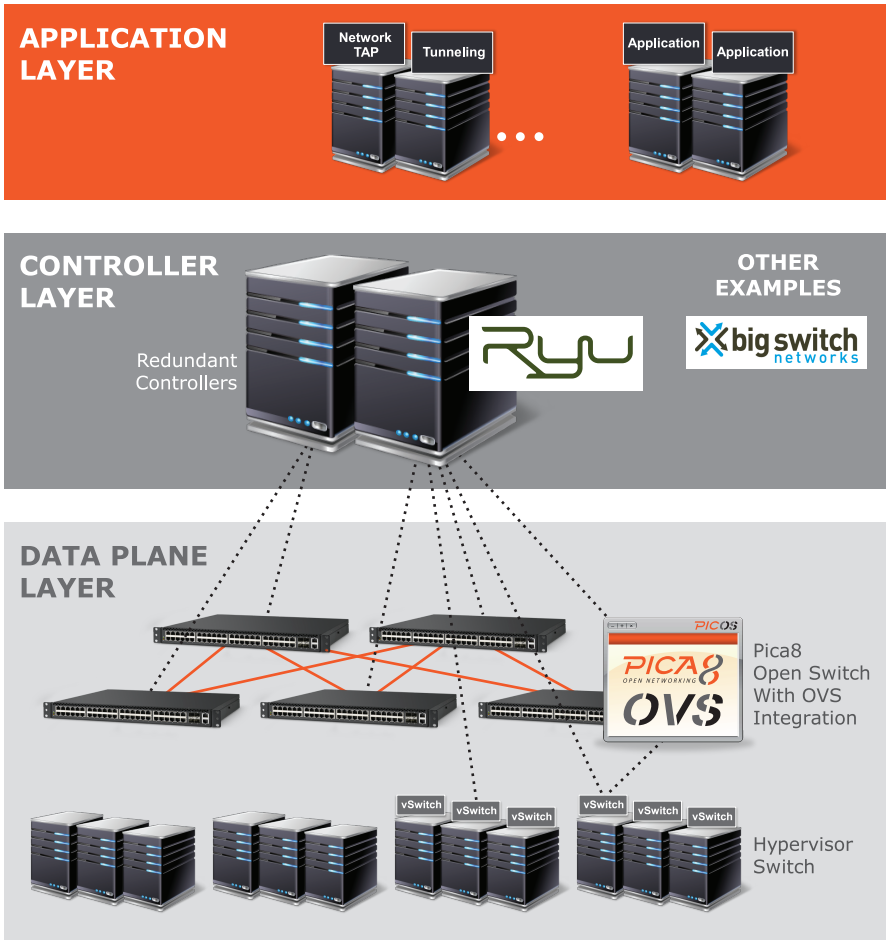
Open Systems for Software Defined Networking (SDN)

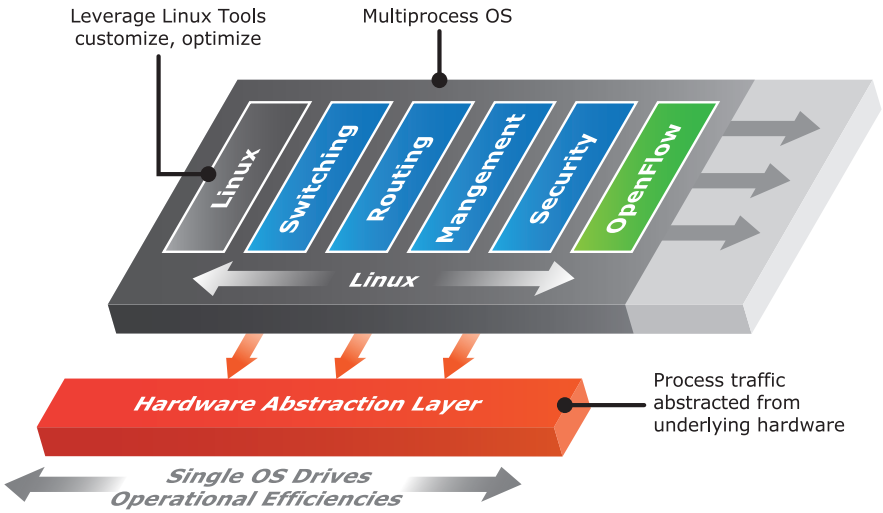


The First Hardware Agnostic, Open Network Operating System

Pica8™ is the first in the world to offer hardware-agnostic open switches. A pioneer in software-defined networking (SDN), we pair high-performance, white box switch hardware with PicOS: our hardware-agnostic, open network operating system that supports standards-based Layer 2 / Layer 3 protocols and Industry-leading OpenFlow* 1.3. In one complete package, Pica8 provides the physical switch, comprehensive switching and routing features, and the fulfilled promise of open networking.

What makes PicOS open?

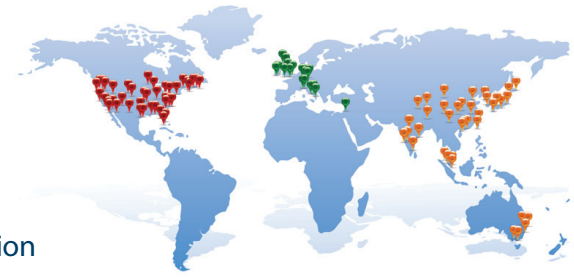
- **PicOS is hardware agnostic**: because of PicOS's hardware abstraction layer, the operating system is not tightly coupled to any switching ASIC, CPU or memory hardware. We continue to expand our ODM partners, offering a portfolio of pre-qualified white box, bare metal switches to select from
- **Debian Linux is exposed**, so you can use your existing tools (such as Puppet, Chef or CFEngine) for hands-free provisioning and myriad APIs through the Debian-Linux environment, helping you personalize Pica8 switches to support your open network
- **PicOS supports OpenFlow 1.3**, through Open vSwitch (OVS) v1.9 integration: OVS runs as a process within PicOS, providing the OpenFlow interface for external programmability



* Only OpenFlow features available in hardware are supported, to ensure optimum performance

Automation for Agile Infrastructure

Corporate Overview



Founded: 2004

North America HQ: Santa Clara, CA

Market-leading supplier of automation solutions for:

- Network test and test lab efficiency, productivity and savings
- IT infrastructure self-service for DevOPS agility and cloud evolution

Mature, proven technology:

- Hundreds of customer deployments
- Millions of infrastructure elements managed
- $Billions in infrastructure managed

Automation Platform

Comprehensive Automation Framework

- Resource management
- Heterogeneous environment design + workflow authoring
- Reporting and business intelligence
- Self service portal

Object library-based architecture

- Supports & enforces best practices
- Optimizes programming staff skills
- Achieves high ROI through ease of maintenance and scalability

Any-Stack Integration

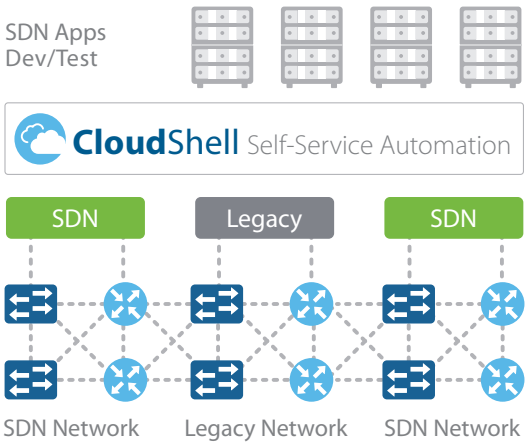
- Key API integration libraries + open driver creation
- Freedom from vendor roadmaps, allows integration with legacy, home-grown components
- Overcomes interface silos

User-friendly GUI-based automation design

- Break open expertise bottlenecks
- Systematize knowledge, increase reusability
- Maximize total team productivity

SDN Self-Service Automation

- SDNs offer northbound API's for applications to drive network behavior
- Yet SDN adopters will need to manage heterogeneous network environments with both legacy and SDN elements
- CloudShell provides the means to automate the delivery of SDN/legacy network environments for DevOPS network application development, testing and deployment



TestShell

TestShell is an object-oriented test and lab automation platform. It delivers powerful lab infrastructure management, and test automation solutions for network, data center, tech support, and demo/PoC lab environments. TestShell is deployed by leading service providers, technology manufacturers, enterprise and government IT departments around the world.

TestShell's object-oriented architecture revolutionizes network, data center and cloud infrastructure testing by:

- Dramatically increasing the efficiency and ROI of test infrastructure through improved resource sharing
- Simplifying the creation, maintenance and re-use of automated device control interfaces, provisioning actions and testing tasks through a shared object library
- Empowering non-programmers to create, save, share, integrate and reuse complex test topologies and automation workflows
- Enabling seamless hand-offs of topologies and automation workflows between developers, architects, QA teams, pre-production, technical support, field operations and customer engineers

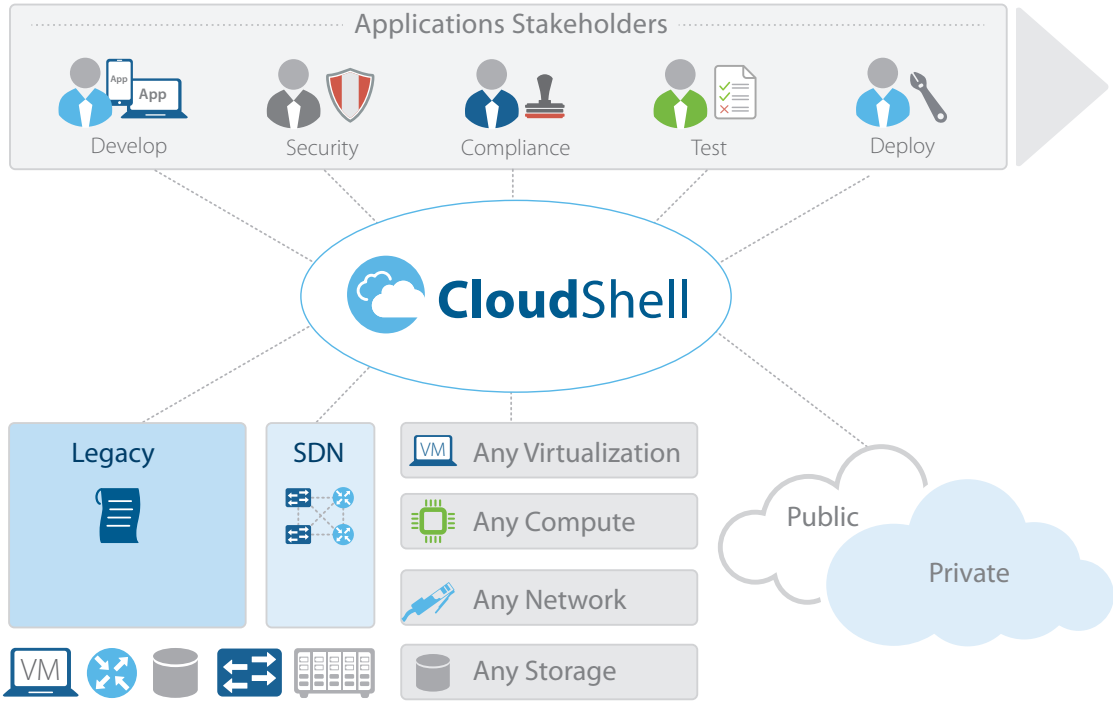
CloudShell

CloudShell is a self-service automation platform for heterogeneous, multi-generational IT infrastructures and networks. It helps infrastructure and networking teams to deliver agile, end-to-end infrastructure to application delivery stakeholders including developers, testers, compliance and security engineers, and deployers.

Self-service automation of heterogeneous, multi-generational IT infrastructure

- Legacy systems and stack
- Traditional datacenter and network environments
- Industry-specific IT components
- Software-Defined Networking
- Private and public clouds

Helps IT infrastructure and network teams achieve DevOPS agility



For more information about QualiSystems, visit our website at
www.qualisystems.com

Software Defined Networking Solutions
Enable Network Wide Services via SDN Applications

Radware SDN applications improve application security, performance and availability by programming the SDN to collect data and optimally forward traffic to deliver network services. The native component of the new network stack introduced by SDN includes the data plane networking devices and the control plane SDN controllers. The Radware SDN applications constructing the SDN application control plane, interact with the SDN controller using dedicated SDN drivers and work together with the Radware systems' using the Radware API to collect data throughout the application infrastructure using specific data collection drivers.

With Radware SDN applications, ADC and security services transform from device-based solutions requiring a static traffic forwarding configuration, to network wide services that intelligently divert traffic to service engines. Network services can scale to support larger networks at lower capital and operational cost. By building SDN applications that continuously interact with the SDN control plane and program the network (and by leveraging the Radware Virtual Application Delivery Infrastructure (VADI) architecture – which enables pooling of disperse resources to operate uniformly) Radware enables an anywhere and everywhere network service paradigm.

Key benefits from the Radware SDN network service infrastructure include:

- **More intelligent application delivery and security decisions** throughout the network break existing network barriers when developing business applications. Every application everywhere is entitled for advanced services.

- **Simpler implementation** of network services allows improved operational efficiency of network management alongside application changes. Not every project needs to become a networking project.

- **Lower overall network service solution costs** – as network service delivery is partially offloaded to the SDN, there is no need to invest in excess network service appliances and capacity. Deploy network services as needed, and use by many tenants and applications throughout the datacenter.

- **Greater scalability** – scale your network services throughout the network. No more limited areas are protected or load balanced. Offer uniform services throughout the SDN.

- **Easier operation** – changing and managing security and ADC functionality becomes simpler as the deployment operates as if it is centralized. Not only does SDN streamline network operations, but Radware SDN applications streamline network service operations.

DDoS Protection as a Native SDN Application

DefenseFlow is an SDN application that enables network operators to program the network to provide DDoS protection as a native network service. DefenseFlow features an adaptive behavioral-based DoS attack detection engine and a traffic diversion mechanism that utilizes the programmable characteristics of the software defined network elements for attack cleansing. Designed as part of the Radware SDN application framework, DefenseFlow operates in any SDN enabled network infrastructure.

Legacy DDoS protection solutions that make use of scrubbing centers are costly: need hardware detectors in every network location; BGP for traffic diversion; and GRE tunnels to forward the traffic to its designated network object. With SDN, a DDoS protection solution turns into a software application that adds intelligence to the network – no need for additional hardware, BGP or GRE operations.

DefenseFlow equips network operators with the following key advantages:

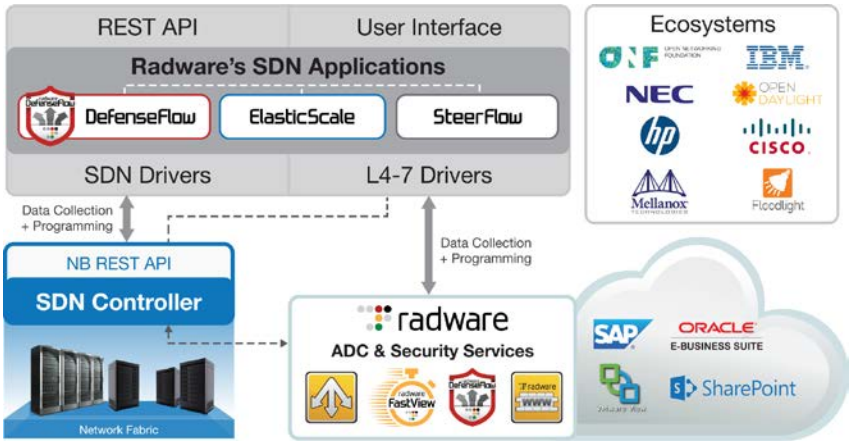
- **Unprecedented coverage against** all type of network DDoS attacks
- **Best design for attack mitigation**
    - Attack detection is always performed out of path (OOP)
    - During attack only suspicious traffic is diverted through the mitigation device
- **Most scalable mitigation solution** – DefensePro mitigation devices can be placed in any location, DefenseFlow diverts the traffic to the nearest mitigation device.

SDN for a Scalable Application Delivery Network

Radware's ElasticScale is an SDN application that wraps existing network service virtual appliances and provides provisioning and traffic distribution logic to consistently deliver network services in an elastic demand environment. ElasticScale can be utilized for service provider internal services, managed services to end customers and can providers adopt network function virtualization paradigms.

ElasticScale offers network operators the following key features and benefits:

- Ultra scalable traffic steering solution (100's of Gbps)
- Ultra scalable load balancing solution
- Based on industry leading, carrier grade Alteon load balancing product line
- Support for leading hypervisors (oXen/KVM/Hyper-V/ESXi)
- Compatible with leading SDN controllers; OpenDaylight, Cisco XNC, NEC pFlow & HP Flare
- Seamless integration with OpenStack and vCloud Director
- Runs over any physical SDN network equipment



Partnering for Success: Our SDN Ecosystem

The SDN eco-system is a critical focus for Radware. Through partnerships with the industry's leading SDN forums and vendors, Radware can ensure customers that our application delivery and security solutions integrate successfully into target architectures.

Radware is an active contributor in the following industry and vendor SDN initiatives: Big Switch Networks, Cisco Open Network Environment (ONE), Floodlight, HP Virtual Application Networks, IBM Distributed Overlay Virtual Ethernet (DOVE), NEC, Mellanox, Open Daylight Project, and the Open Networking Forum (ONF). Radware is also a member of VMware's NSX partner ecosystem for network functions virtualization (NFV).

Learn More

To learn more about how Radware's SDN solutions can enable you to get the most of your business and IT investments, email us at info@radware.com or go to www.radware.com.