Market Report

2016 Mega NFV Report Pt. 1: MANO and NFVI

The Trusted News and Resource Site for SDx, SDN, NFV, Cloud and Virtualization Infrastructure

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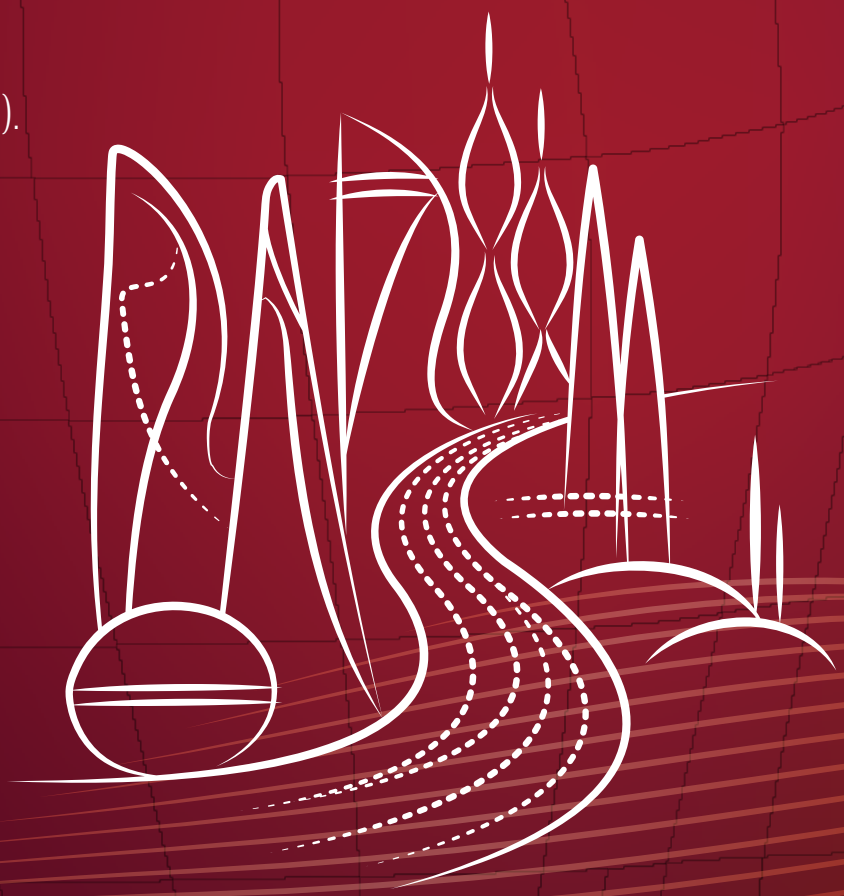

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Introduction – NFV Platforms Grow Up

Welcome to the 2016 Mega Network Functions Virtualization (NFV) Report Pt. 1: MANO and NFVI, which gives you a full update into the trends and progress of the NFV market.

The hallmark of NFV is that it can deliver network functionality via software running on industry-standard commercial off-the-shelf (COTS) hardware. The main advantages are that it can provide networking needs of a service provider or enterprises' application on standard server and storage infrastructures. New services do not require new hardware infrastructure – simply software installation.

NFV decouples network services from the hardware that delivers them. As a result, functions, such as network address translation (NAT), firewalling, intrusion detection, domain name service (DNS), and even complete suites like EPC (Evolved Packet Core) services can be delivered in software and deployed on general purpose appliances. This gives organizations a lot more flexibility in the way they design, deploy and manage their network services.

History: Beginnings in the ETSI ISG

NFV originated in the service provider community as operators looked for ways to cut costs and accelerate the roll out of profitable services to monetize their networks and grow their revenues. Hardware-based network appliances, which are typically expensive and complex to deploy and manage, were limiting the providers' ability to consolidate functionality and quickly trial new services.

By using a virtualized environment, providers wanted to be able to deploy network functionality whenever and wherever it was needed; they didn't want to be tied to the capabilities of a specific appliance or topology. They felt if they could decouple the network services from the hardware, it would allow them to deploy networking components that could truly fit and support a fully virtualized infrastructure, including servers, storage and even other networks.

As NFV gained momentum, operators gathered within the European Telecommunications Standards Institute's (ETSI) and created the Industry Specification Group (ISG) for NFV to accelerate the progress of virtualizing network functions. Launched in January of 2013, the ETSI ISG for NFV has been working to develop the requirements and architecture of virtualized network functions in a telecommunication's network. It included these components of the NFV framework:

- **Virtualized Network Functions (VNFs)** – The software implementation of a network function. We will have more detailed analysis in Part 2 of this series of NFV reports, which will be published in mid-April.
- **NFV Infrastructure (NFVI)** – The physical resources (compute, storage, network) and the virtual instantiations that make up the infrastructure.
- **NFV Management and Orchestration (NFV MANO)** – The management and control layer that focuses on all the virtualization-specific management tasks required throughout the lifecycle of the VNF.

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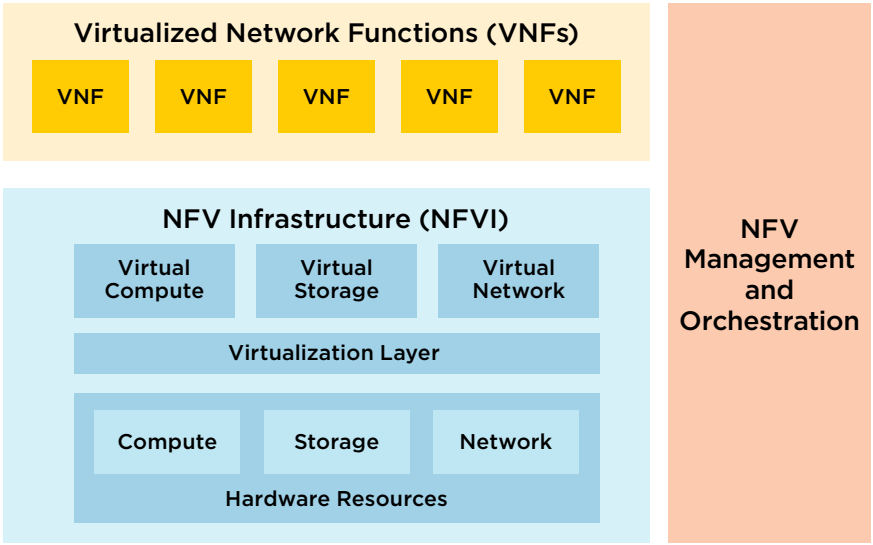

Adapted from ETSI publication GS NFV 002: Network Functions Virtualization (NFV); Architectural Framework

HIGH LEVEL NFV FRAMEWORK

These components each contain a number of different NFV technologies, which organizations can deploy to achieve the flexibility, scalability, and efficiencies they require. Let's look at the technologies/solutions contained within each component (functional block) of an NFV architecture.

Since the original ETSI model for NFV was released, some operators have clamored for a more rapid and organic development of NFV platforms. Some operators have even put together their own technology programs, including developing their own open source projects which they then donate to the community.

Managing NFV MANO and Beyond

So, how do we make sense of this new world of NFV and MANO? This report presents an overview of the emerging NFV architectures and designs, leading use cases applications, and technology supplied by vendors in the NFV market.

Our analysis includes examination of hundreds of our news and analysis articles, in-depth interviews we have conducted with technology vendors and end users, and the results of the SDxCentral NFV Survey, which was posted on the SDxCentral site. This survey had 79 end-user respondents, including service providers, (46%), cloud service providers (14%), enterprise end users (14%) and a variety of others (24%) from user communities.

In addition to an overview of the technology and an analysis of customer expectations, we also collected data from almost 100 companies. The product information from technology vendors is available at the end of this report.

(Editor's note: This megareport has been split into two separate products – Part 1 of our 2016 Mega NFV Report covers MANO and NFVI and the second part of the series, the 2016 Mega NFV Report Pt II: VNFs and VNFCs will be released in a of couple weeks. They each contain commonalities but have been customized to address each market segment.)

What you can expect from this report:

- An overview of NFV and NFV MANO, describing the evolution of architectural components and potential benefits.
- General use cases and applications for NFV technologies, including feedback from our users in our 2016 NFV Survey.
- Details on different vendor offerings to provide early insights into the capabilities and maturity of different solutions.

Thank you for downloading this report, we hope you will find it a useful resource, as you look to understand and adopt NFV technologies.

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Investment Benefits of NFV in NFVI and MANO

Network operators, including enterprises and service providers, are looking at NFV investment to build new services they want to deliver with their networks. Part of this involves reducing costs on NFVI and making MANO more agile. To build an NFV business case, operators need evidence that they can accelerate revenue while reducing costs associated with service deployment and operations.

Operators are in the process of identifying the return on investment (ROI) for NFV. The goal is a reduction in expenditures (both capex and opex) and by new revenue generated by NFV-related services.

In identifying the business case for NFV, key questions include:

- What are the specific revenue-generating services enabled by NFV?
- Which network elements are good candidates for virtualization?
- How does NFV reduce capital and operating costs?

The NFV Business Case

It's worth a closer look how service providers make this determination of the business case for NFV and all of the factors involved. In general, NFV promises to enable organizations to reduce expenses and potentially accelerate.

Below is a full list of the common business justifications for NFV.

Reduce capital expenditures especially in the NFVI:

- The use of commercial off-the-shelf (COTS) hardware and servers reduces hardware costs. A wide variety of providers can offer these servers, increasing the volume and competition in the marketplace and, ultimately, driving down costs.
- By delivering the services in software, organizations are no longer forced to rely on specialized hardware to run network functions. This means the premium that a handful of vendors could charge for their proprietary hardware is no longer applicable or justifiable.
- A single, common server architecture can be used to build in the redundancy and availability organizations require within their data center environment. No longer do organizations need to purchase and maintain expensive equipment to keep as spares; in the event of a failure, the shared virtualized infrastructure can simply move workloads to ensure ongoing capacity and performance.
- The ability to use a shared infrastructure from a cloud provider(s) to run the functions required by an organization turns the capital expense to an operational one to increase capital efficiencies. By renting instead of buying the equipment outright, organizations can take advantage of pay-as-you-grow models and avoid costly and wasteful overprovisioning.
- A side benefit of using less expensive commodity hardware is that an organization can potentially cycle the hardware more often to improve the overall performance of the network. By upgrading the network every 2 to 3 years, instead of the traditional 5 to 7, an organization can continue to effectively address the changing demands placed on their network and increase the value captured throughout the lifetime of those servers.

Reduce operational expenditures around both NFVI and NFV MANO:

- Software enables organizations to quickly and easily move and scale functionality to address changing needs and maximize the utility of the commodity hardware. A single server can be used to provide a variety of capabilities, eliminating the need to deploy, manage and maintain specialized hardware for specialized functions.
- With the use of more efficient hardware, organizations can reduce the space, power and cooling costs associated with their deployments. Standardized hardware often leverages the techniques perfected in massive data centers by cloud service providers, such as Facebook and Google, to further streamline operations.

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- Common automation and operating procedures utilized by commodity hardware simplifies roll out and ongoing management. Standardized hardware, as well as standardized software, such as hypervisors and orchestration systems, often use automation scripts and platforms that deliver, on average, management efficiencies between 1:10/1:100 to 1:1000.
- Overall, virtualized functions provide greater flexibility and less complexity in management; organizations can quickly and easily templat-ize deployments to make it simple to move or redeploy functionality across the organization.

Accelerate time-to-market for new services:

- Virtualized functions can be easily installed and provisioned to enable an organization to quickly deploy services when, and where they are needed.
- Virtualized functions are conducive to enabling organizations to trial new services, without incurring much risk. Standardized frameworks and the ability to dynamically recover from failures by using an orchestrating framework enables organizations to dramatically decrease the risk of deploying new products from vendors. The low costs and flexibility of being able to move and scale functionality, as needed, drives service innovation. Proof of Concepts (POCs) and trials can be run faster, in smaller scale environments; "fail fast" prototyping can be achieved, so the organization can adjust and fine-tune their offerings to be confident in wide-scale deployments.
- The ability to run virtual services on top of physical underlay networks means organizations do not need to incur the time or costs of having to forklift upgrade their existing systems to add new services.

Deliver Agility and Flexibility:

- Because organizations don't have to amortize the cost of expensive equipment or handle "step-function" capital equipment acquisitions (e.g. where they need to make a $M investment to bring up a new service for a single customer), they can quickly and easily address customers' demands. Now, they can provision a couple of servers to offer one-time use or short-term use services.
- The ability to easily tear down, move, scale and configure services as the demands of customers or the business changes gives organizations the ability to bring up services anywhere in the world, any time.

These trends are confirmed from our discussions with industry experts as well as some of the survey data we have collected.

How Operators Realize ROI in NFV

While there has been some criticism of the NFV approach both in the analyst and service provider community, progress is being made. Despite the skepticism, NFV accelerated in 2015 and some important deployments have been announced, including production deployments at global service providers including AT&T, Telefonica, Telstra, SK Telecom, Swisscom, Vodacom, among many others.

2016 appears to be the year that NFV moves from proofs of concept (PoCs) and trials and into the real world with commercial production.

More and more of the network infrastructure will come into scope (due to improved NFV/SDN hardware and software). In addition, the cost and business benefits for NFV implementation are expected to increase over time due to the following factors:

- Improved maturity and experience from NFV/SDN transformation
- Continued increase in processing and I/O capabilities of commercial (x86) server and OS software
- Improved capabilities and performance of NFV applications

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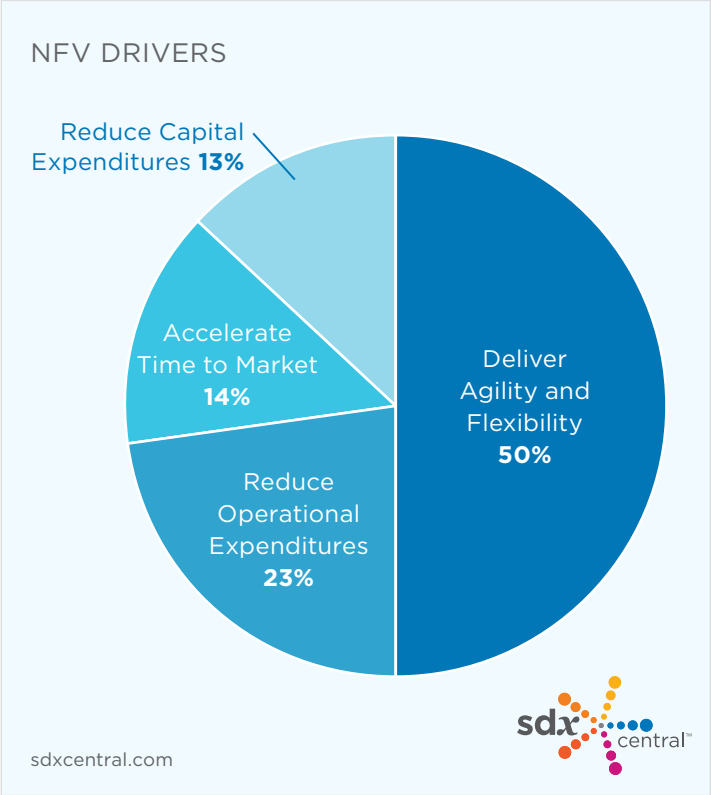
- Improved efficiency of capacity utilization in a virtual environment – reduction in capacity growth, better capacity planning
- Ability to consolidate (reduce the number of) hardware boxes

While it's hard for operators to quantify the exact potential savings, some independent analysts have taken a shot at it. For example, Doyle Research estimates that NFV can provide capex savings in the range of 20 to 35 percent of certain network elements.

NFV Platforms: What Users Want

As described above, there are many commonly described market drivers for NFV, including agility and flexibility, faster time to market, reduced capital expenditures, and reduced operational expenditures. We gathered some feedback from end users to see what they are looking for in our 2016 NFV Survey.

When asked to name the primary driver for NFV technology, the majority of respondents (50%) to our NFV Survey said it was NFV's ability to "Deliver Agility and Flexibility". "Accelerate Time-to-Market" was identified by 14%, while the remainder of the respondents chose savings as the primary reason to adopt NFV – 23% focused on the operational savings of NFV, while 13% said it was NFV's ability to reduce capital expenditures that was so attractive.



NFV Architecture

The NFV architecture enables network functions to be standardized, allowing for the construction and management of function or functions that best support the organization's environment. This makes it easy for service providers and enterprises to deploy new services faster, while maximizing their investments in existing platforms.

As described in the introduction, there are three major components to an NFV framework:

1. VNFs – the virtual implementation of a physical network function.
2. NFVI – the physical resources (compute, storage, network) and the virtual instantiations that make up the infrastructure.
3. NFV MANO – the management and control layer that focuses on all the virtualization-specific management tasks required throughout the lifecycle of the VNF.

These components fit together in the architecture depicted in the diagram below. Note that this report focuses on the NFVI at the bottom left of the diagram and the MANO element, the pieces on the right side of the diagram. Next month, the second part of our NFV series will focus on VNFs.

These components depicted in the diagram each contain a number of different NFV technologies which organizations can deploy to achieve the flexibility, scalability and efficiencies they require. Let's look at the technologies/solutions contained within each component (functional block) of an NFV architecture, focusing on NFVI, as well as the elements in MANO including the VIM, the VNFM, and the NFVO.

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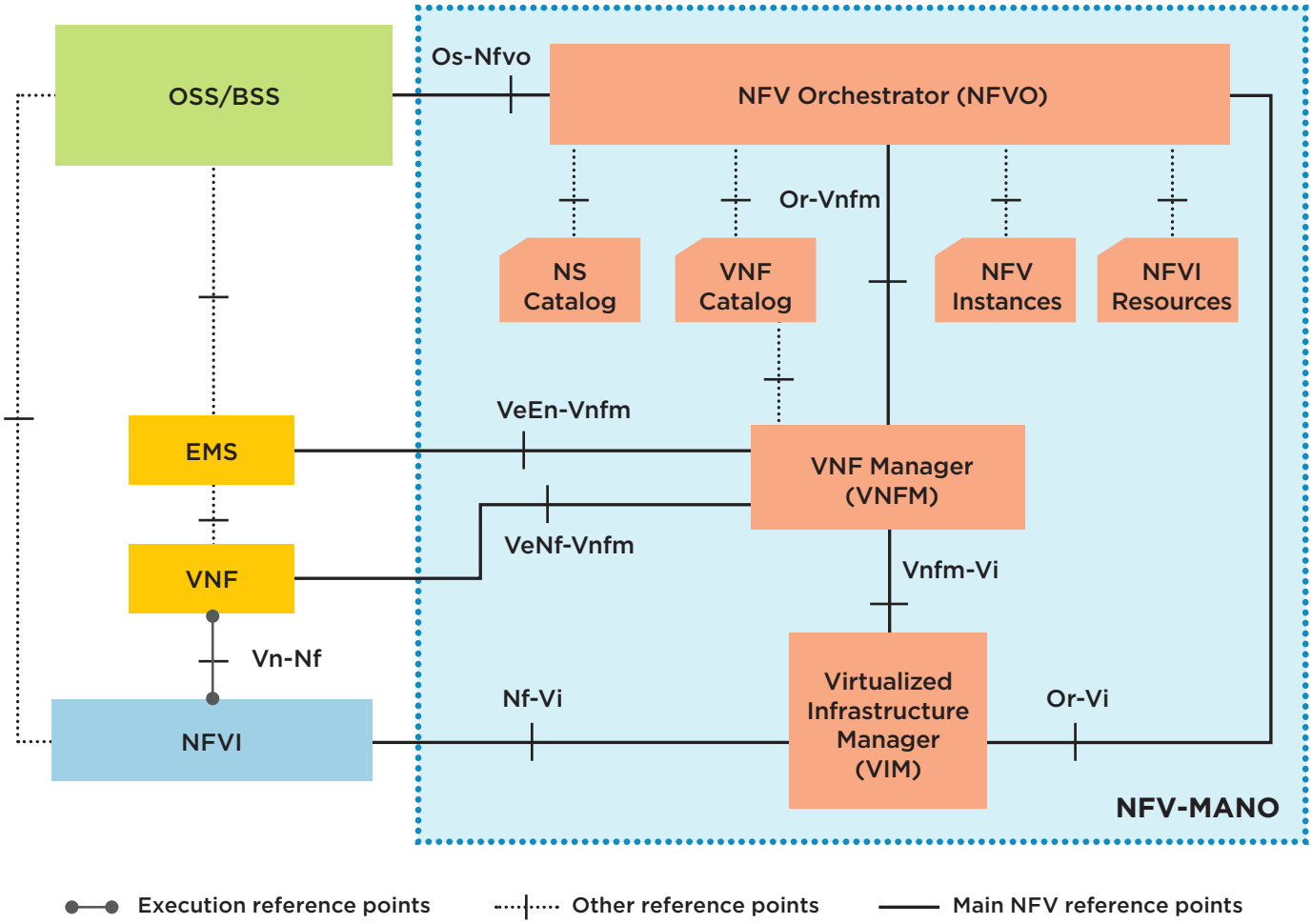
Based on user feedback, this ETSI NFV architecture has become the roadmap for the NFV industry. When our survey asked if the ETSI ISG architecture was seen as the primary source of standards for the NFV ecosystem, respondents overwhelming replied “Yes” (91%).



A graphical depiction of the NFV architecture, with the MANO components on the right side in blue.

VIM Functions and Importance

The virtualized infrastructure manager (VIM) is a key component of the NFV-MANO architectural framework. It is responsible for controlling and managing the NFVI compute, storage, and network resources, usually within one operator’s infrastructure domain.

The functional blocks help standardize the functions of virtual networking to increase interoperability of software-defined networking elements. VIMs can also handle hardware in a multi-domain environment or may be optimized for a specific NFVI environment.

The VIM is responsible for managing the virtualized infrastructure of an NFV-based solution. VIM operations include:

- Keeping an inventory of the allocation of virtual resources to physical resources. This allows the VIM to orchestrate the allocation, upgrade, release, and reclamation of NFVI resources and optimize their use.

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- Supporting the management of VNF forwarding graphs by organizing virtual links, networks, subnets, and ports. The VIM also manages security group policies to ensure access control.
- Managing a repository of NFVI hardware resources (compute, storage, networking) and software resources (hypervisors), along with the discovery of the capabilities and features to optimize the use of such resources.

The VIM performs other functions as well – such as collecting performance and fault information via notifications; managing software images (add, delete, update, query, copy) as requested by other NFV-MANO functional blocks; and managing catalogues of virtualized resources that can be consumed from the NFVI. In summary, the VIM is the management glue between hardware and software in the NFV world.

VIMs are critical to realizing the business benefits enabled by the NFV architecture. They coordinate the physical resources necessary to deliver network services. This is particularly visible for infrastructure-as-a-service (IaaS) providers. The IaaS providers have to ensure that their servers, networks, and storage work smoothly with those onsite. They must ensure that resources can be dynamically allocated based on requirements, which is a key feature of cloud computing.

When a VIM is described, many think of OpenStack VIM software. It's been tested and is in use in provider networks, such as NTT, South Korea Telecom, Deutsche Telekom, AT&T and Verizon. There has been some industry criticism of OpenStack and whether it can be a "carrier class" platform for NFV. There are other major competing VIMs including VMware's vRealize suite and to a lesser extent, CloudStack. As we will detail later, a number of open source projects have been founded to add improved functionality to OpenStack and other NFV platforms to make them "carrier class."

Our survey asked users about the maturity of the OpenStack VIM, and 66% of respondents to the survey said it was "Coming to Maturity, But Needs More Work"; 26% felt the software was "Not Mature at All", while 8% were on the other side of the spectrum, believing it was "Complete and Mature".

The Role of the VNFM

The VNFM is responsible for the lifecycle management of VNFs under the control of the NFVO, which it achieves by instructing the VIM. VNFM operations include:

- Instantiation of VNFs
- Scaling of VNFs
- Updating and/or upgrading VNFs
- Termination of VNFs

VNFs are critical to realizing the business benefits outlined by the NFV architecture. They deliver the actual network functions that create value. But they aren't autonomous. They require VNFMs. VNFMs are critical for scaling, changing operations, adding new resources, and communicating the states of VNFs to other functional blocks in the NFV-MANO architecture.

The VNFM also works in concert with other NFV-MANO functional blocks, such as the VIM and the NFVO, to help increase the interoperability of software-defined networking elements.

A VNFM may be assigned the management of a single VNF instance or multiple VNF instances. The managed VNFs can be of the same or different types. In the original design, VNF manager functions are assumed to be generic and can be applied to any VNF.

Ultimately, the VNFM maintains the virtualized resources that support the VNF functionality without interfering with the logical functions performed by the VNFs. The services provided by the VNFM can be employed by authenticated and properly authorized NFV management and orchestration functions (e.g., functions that manage network services).

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Inside the NFVO

The NFV Orchestrator performs two primary functions including resource orchestration and network service orchestration, as well as other functions.

Resource orchestration is important to ensure there are adequate compute, storage and network resources available to provide a network service. To meet that objective NFV Orchestrator (NFVO) can work either with the VIM or directly with NFVI resources depending on the requirements and architecture as it has the ability to coordinate, authorize, release and engage NFVI resources independently of any specific VIM. It also provides governance of VNF instances sharing resources of the NFVI infrastructure.

This capability is important to solve the new challenges faced by providers as they create new architectures. For example, it might be more important to deploy an NFV-based solution across different points of presence (POPs) or within one POP – but across multiple resources. This would not be easily implemented or perhaps not possible. But with NFV MANO and NFV Orchestrator, service providers now have this capability.

To provide service orchestration, the NFVO creates end-to-end service among different VNFs (that may be managed by different VNFMs) by coordinating with VNFMs as well as the VIMs through their northbound APIs.

NFV Open Source Projects Proliferate

As we have described, the ETSI architecture has gone a long way to defining the NFV platform. On the development front, open source development is accelerating and adding to the code available for NFV platforms.

One of the main goals of operators is to accelerate the development of a "carrier class" platform that can deliver better scale and reliability than OpenStack, one of the most popular open source NFV platforms. Another goal is to create sufficiently rich MANO and NFVI open source systems that replace portions of proprietary hardware management platforms as well as OSS and BSS stacks. As these open source projects grow, technology vendors are positioning themselves as well, borrowing some open source technologies as well as presenting their own improvement through integration. The result is an explosion of different approaches and competing technologies.

While the ETSI MANO architectural framework remains the de facto guide to NFV architectures, that does not mean it is the only game in town. As described, many operators are doing their own integration work, including developing open source code which they then contribute to the public domain.

There has been an explosion of NFV-related projects in the last year – especially in the open source community. In 2014, the Linux Foundation announced the Open Platform for NFV Project (OPNFV), which is an open source, carrier-grade integrated platform that aims to help bring new NFV products and services to the industry faster. Since then, a number of operators have released their own technology into the open source market. Some of these include Open O (China Mobile), TCS Telco Cloud (Tata), **Gohan** (NTT), and **OpenMANO** (Telefónica).

In December of 2015, the OPNFV board voted to broaden into areas including management and orchestration (MANO), setting up the **open source** project to design a full reference implementation for **network functions virtualization (NFV)**. The decision means the project's scope now includes all of **NFV**. Until then, **OPNFV** was limited to virtualized network functions (VNFs) and accompanying lower-layer management.

"This means that OPNFV **projects** can expand, as needed, and the community is free to incubate and propose projects on additional topics, including MANO," wrote OPNFV Director Heather Kirksey, in a blog post.

The diagram shows the original mission of OPNFV and where it is starting to expand for the future.

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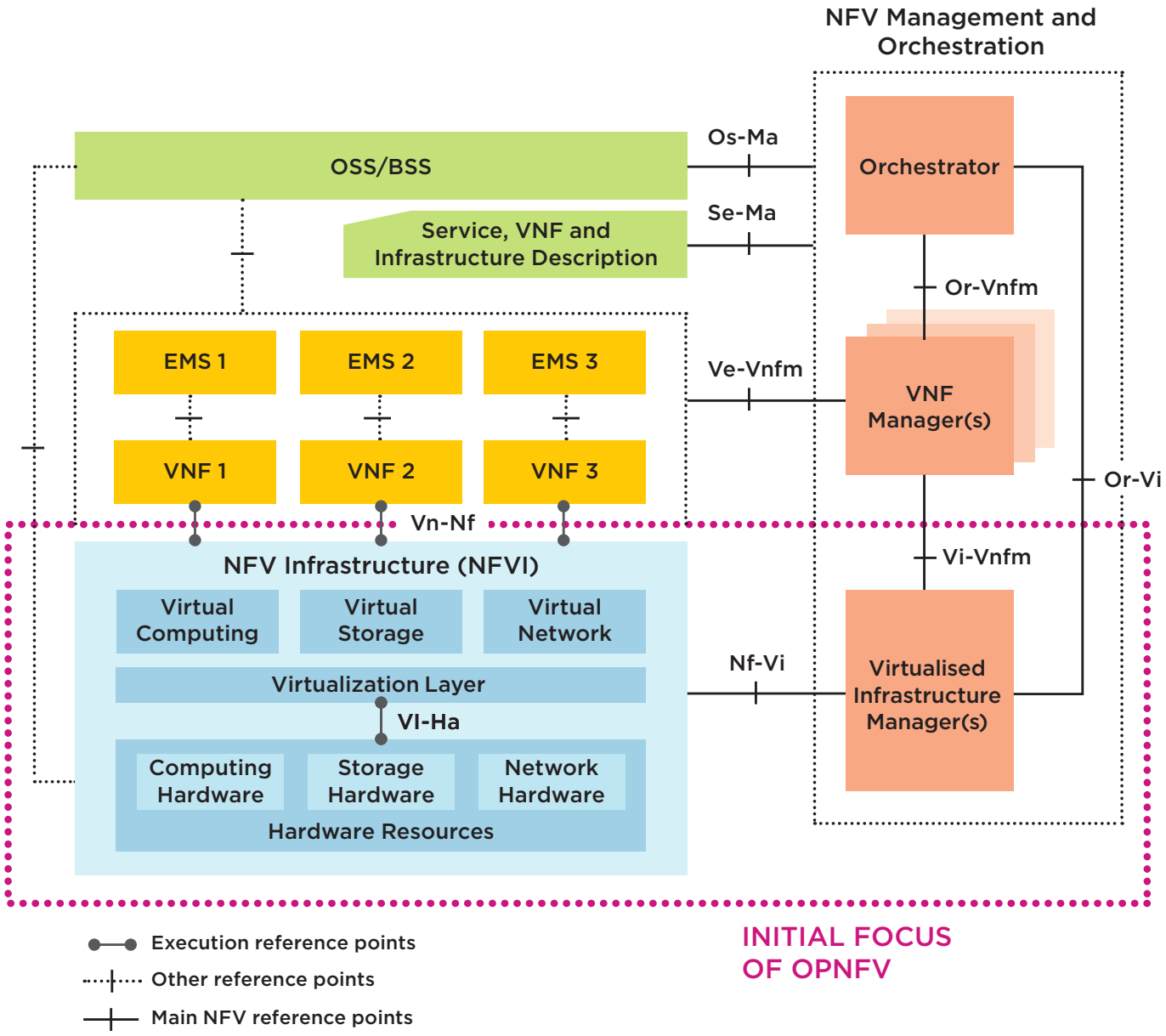

NFV REFERENCE ARCHITECTURAL FRAMEWORK

Adapted from ETSI publication GS NFV 002: Network Functions Virtualization (NFV); Architectural Framework

Another significant open source effort comes from China Mobile's Open-O is designed to provide interfaces up to the operations support system (OSS) and down to the VNF manager and VIM. Open-O intends to build a network service catalogue and a VNF catalogue. Earlier this year at Mobile World Congress, it announced further support, including a $60 million dollar investment from Huawei in its development.

Some other service-provider and system integrator backed efforts include:

- Tata Consultancy Services' service orchestration is an open source framework for NFV. It's part of Tata's Telco Cloud platform.

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- **OpenMANO**, Telefonica's open source framework for NFV MANO, debuted at Mobile World Congress in 2015, when **Telefónica announced** it was uploading its VIM and NFV orchestrator to a Github repository. OpenMANO is an open source project aiming to provide a practical implementation of the reference architecture for MANO. It forms the core of OSM described in the next bullet.
- The Open Source MANO (OSM) community launched in February of 2016 at **Mobile World Congress**. It intends to focus on delivering a management and orchestration (MANO) stack aligned with the ETSI framework. The project will initially integrate **open source** software from **Telefónica**'s OpenMANO project, **Canonical**'s Juju-generic VNF Manager, and the **Rift.io** orchestrator.
- In addition to operators creating MANO-related open source groups, the **OpenStack Project** has created **Tacker, an open source VNFM**. And the vendor **GigaSpaces** has established **Cloudify**, a cloud orchestrator

Don Clarke, a principal architect of network **technologies** at **CableLabs**, recently told SDxCentral that some operators say they are committed to NFV but want to control their destiny in MANO. "A number of MANO-related open source communities are coalescing around their own flavor of MANO," he says. "I think it's because when you're going to the MANO part [of the **ETSI NFV** framework], you touch the strategic direction of these operators. MANO is a difficult area for everyone to agree."

"This is why ETSI NFV has taken a bottom-up approach to MANO," says Clarke. "Getting alignment amongst the network operators has been difficult, but we have succeeded because we have taken a bottom-up approach to avoid impinging on individual operator strategies for OSS."

Although ETSI has made efforts to integrate these open source projects into its community and promote a concerted effort on standards, it's clear that open source projects can take on a life of their own. One thing is clear by the various open source groups: Operators appear committed to using open source as a path to accelerating their development of NFV platforms. It's clear that different combinations of open source technology will find its way into global service provider networks.

NFV Orchestration and OSS

OSS technology is often mentioned in the same breath of NFV and MANO because OSS technology is crucial to implementing business processes for service deployment – including functions such as provisioning, billing, service assurance, and fulfillment. OSS technology tends to be varied and often custom-developed by the IT side of an operator's technology department.

Many operators have questions why OSS isn't a bigger topic of discussion in NFV architectures and why it's not more tightly integrated into the NFV-MANO architecture. This was the topic of **SDxCentral's Lifecycle Service Orchestration (LSO) Market Overview Report**, in which some of the feedback from operators indicated they did not think their current OSS systems were compatible with NFV and SDN deployments. At this point, large OSS suppliers including Amdocs, Ericsson, HPE, NEC/Netcracker, Nokia, and Oracle are developing their own hooks into NFV platforms.

In the long run, operators would like to develop end-to-end service orchestration – being referred to as LSO – which requires some further integration with OSS and BSS functions. Traditional OSS systems have been lumped together into the larger "Telco IT" market, because they reside on the IT side of the house, based on a computing and data center network. Because NFV architectures are developing the same COTS server model that is driving data centers, it makes sense that these markets come together. The introduction of SDN and NFV means that service provisioning, orchestration, and management layers of OSS will have to become more tightly integrated with the infrastructure.

In the future, look for OSS technology vendors, IT software vendors, and networking infrastructure vendors to pay more attention to how OSS is integrated with the NFV infrastructure, including MANO. The SDxCentral research team believes this will become a key differentiator in NFV architectures as all operators are interested

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in the end-to-end service provisioning, fulfillment, and monitoring functions of NFV platforms.

NFV Market Landscape

Organizations will need to carefully evaluate the maturity of any NFV solution they are considering; they should understand which capabilities are new versus which are re-purposed to be able to identify potential limitations and barriers to being able to easily adopt emerging capabilities to support future deployment requirements.

The richness of the feature-set for the function it is performing should also be assessed; while not all functionality deployed in proprietary, purpose-built hardware solutions is absolutely necessary, organizations can't afford to make a switch if the capabilities they are going to need are limited or greatly diminished.

Key Criteria in Selecting NFV components and solutions

Below we have created a chart showing the key criteria that will be used to select an NFV platform and its components. There are different aspects based on the type of product it is – you evaluate MANO components different from VNFs, for instance. However, some general capabilities to consider that have surfaced from our conversations with service providers include:

Capability	Consideration
Conformance with the ETSI Framework	To ensure ongoing interoperability, the solution should conform to the ETSI framework and standards being adopted by the industry.
Performance and Reliability	The solution needs to support the environment in which it will be deployed. In the migration towards a virtualized NFVI and replacing what exists today as physical infrastructure, it is critical to understand the limits, bottlenecks that might exist in the virtualization layer.
Scalability	What kind of scale does the overall system provide – does it scale up (consume more cores) out (run across multiple virtual CPUs) or both? Does it have its own management system that can handle multiple instances? How is load managed?
Compatibility	Many organizations have selected a hypervisor platform for strategic or cost reasons. Organizations need to understand if the NFV solution will be compatible with the environment selected. Likewise, what other elements in the infrastructure will this NFV platform need to interact with. Are there any legacy systems that need to be integrated? How will that integration be achieved.
Programmability	Understanding how easy it is to integrate the NFV solution within an organization's existing environment and program the functionality is key to its success. What type of management stack does the solution integrate with today? What type of APIs are provided and are they sufficiently rich to support business goals?
Security	Given that NFV environments are comprised of multiple vendors, who will be involved in the set up and delivery of different NFV elements, it is important to ensure security doesn't suffer. Organizations should understand the security capabilities offered by each and every component of their NFV deployment to ensure best practices are being followed. (Look to understand the communication protocols, hardening capabilities and patch management tools and processes used to secure functionality.)

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Any Specialized Hardware Requirements	Are there any specialized hardware requirements, which could limit the NFV benefits achievable with the system. Examples include requirements for specific NIC hardware or accelerated NICs.
Supported Orchestration Stacks and Management Stacks	What type of EMS is provided with the system and how does it integrate into the existing management frameworks already deployed for NFVI. Does it provide a VNF-Manager or integrate with an existing one? How complete is the VNF-M feature-set and what hypervisor or OSes does the VNF run on? Bare-metal? What is the maturity of the NFVO? What OSS system does it integrate with and what APIs are provided.
Support	Not all service providers have the luxury of having their own development teams with the right level of expertise. Is the vendor providing the solution capable of providing development and integration services? If open source based, who is responsible for fixing bugs and issues that come up? Is there an SLA that makes business sense?

Market Leaders: Who's Doing What

Although there has been a great deal of hype surrounding the NFV market as we head into 2016 the environment can still be characterized as developing – and new single vendor enjoys a huge lead. Most deployments are limited in scope, narrowly focused, and not going as smoothly as would be liked.

Competitive forces in the NFV market can be characterized by three major components: 1) Intra-industry rivals 2) New entrants and 3) Low-cost or free alternatives (open source).

Existing networking vendors including Cisco, Ericsson, HPE, NEC/Netcracker, Nokia, Juniper, Huawei, and others are working to fend off new market entrants by integrating NFV platforms with their existing hardware and software management offerings. Competition is also coming from the virtualization and Linux ecosystem, with companies such as Canonical (Ubuntu), Red Hat, and VMware building their existing virtualization platforms to support NFV.

As mentioned above, open source projects are proliferating and this code is being used to expand the functionality and scalability of NFV platforms. The established vendors are focusing on assembling the write pieces of the pie and becoming active integrators that can help build an NFV platform that is flexible and compatible with open source efforts.

Established Players and Strategies

Most of the existing vendors are trying to build on their existing positions of strength – and using the open source world and partnerships to fill in gaps.

For example, Nokia (formerly Alcatel-Lucent) is developing an end-to-end offering integrating their existing hardware offers with new software components via their CloudBand platform. Ericsson is building on their strength in RAN, OSS, and integration services and focusing on industry partnerships and creating a carrier-class version of OpenStack. NEC is pushing its strength in OSS and billing with the Netcracker division to win new opportunities. Cisco's building on its size with its Tail-F offering and Evolved Services Platform (ESP). And the impact of the Cisco-Ericsson partnership is just beginning to be felt in the marketplace.

Many vendors are basing their architectures on OpenStack technology, which leads to a bit of a conundrum. OpenStack is open source, for sure. But as vendors expand on OpenStack and add their own extension, they are building complexity around OpenStack and eventually as functionality is extended, the products start to look more proprietary. One trend that seems to be occurring is that the networking and software vendors see their role with operators as becoming integrators of the technology.

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market summary

Newer competitors – or competitors from other markets – may not have the resources or experience to develop complete solutions in the service provider market. The alternative is focus on a specific technology. Red Hat, for example doesn't have a product in the NFV Orchestrator or VNFM areas, but it is strong in the NFVI and VIM markets. VMware also is well anchored in the NFVI areas with ESXi, vSphere, and VSAN, while in other functional areas VMware works with partners.

MANO Meets OSS: An Integration Play

Customers in the NFV area are not yet replacing existing business critical components like OSS/BSS systems, which is attracting traditional OSS vendors such as Amdocs, Ericsson, HPE, NEC/Netcracker, and Oracle into the NFV market with their pitch to integrate OSS systems with NFV orchestration functions.

The OSS challenges as well as the lack of maturity in the OpenStack space means that technology vendors will often compete on their ability to develop an integrated MANO offering that can work with their NFV solutions and other legacy systems.

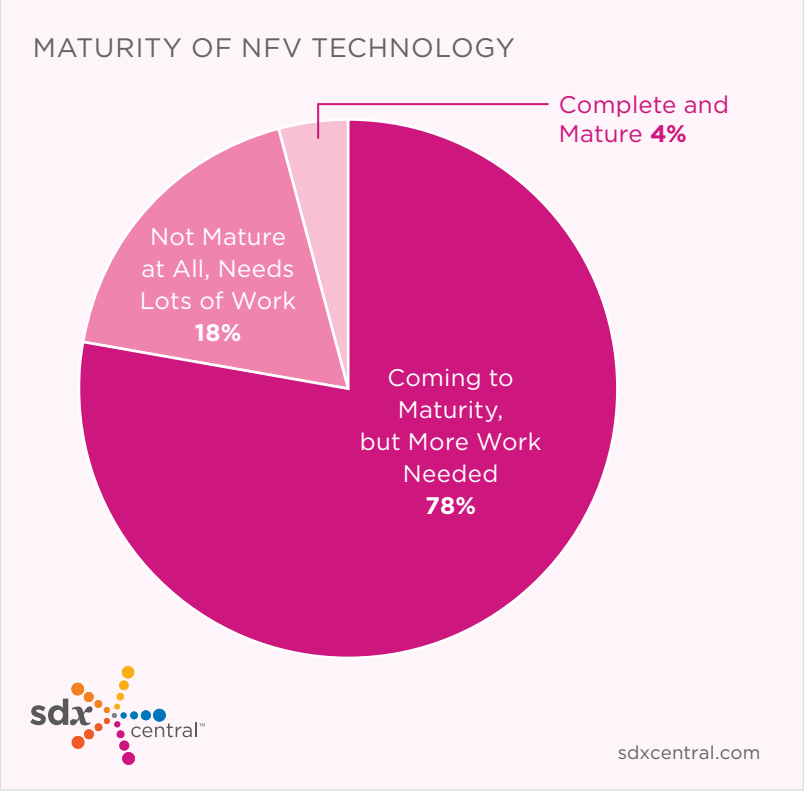
Market Barriers and the User Perspective

Network operators, with a few exceptions, are motivated to invest in NFV, but they are embracing caution as they move from proven operationally sound architectures and technologies. Both operators and vendors have discovered that when moving from labs to production networks it is not only NFV technologies that matter.

There have been some high-profile challenges and changes in direction in the industry. For example, a BT official told attendees of the SDN & OpenFlow World Congress in Dusseldorf last year that it was mulling whether the technology could truly be carrier class and that it would consider competing proprietary solutions.

Perhaps it's foolhardy to think that relatively young open source technology would instantly become carrier-class and scale to meet the needs of millions of customers. Clearly, the large technology vendors are going to do their best to add value to open source solutions and present proprietary hooks and integration strategies that make their technology sticky for customers.

Maybe everybody just needs to be more patient. In our survey of 80 end users, 78% of respondents said they feel NFV technology is starting to mature, but still needs more work. Eighteen percent feel it is "Not Mature at All and Needs a Lot of Work".



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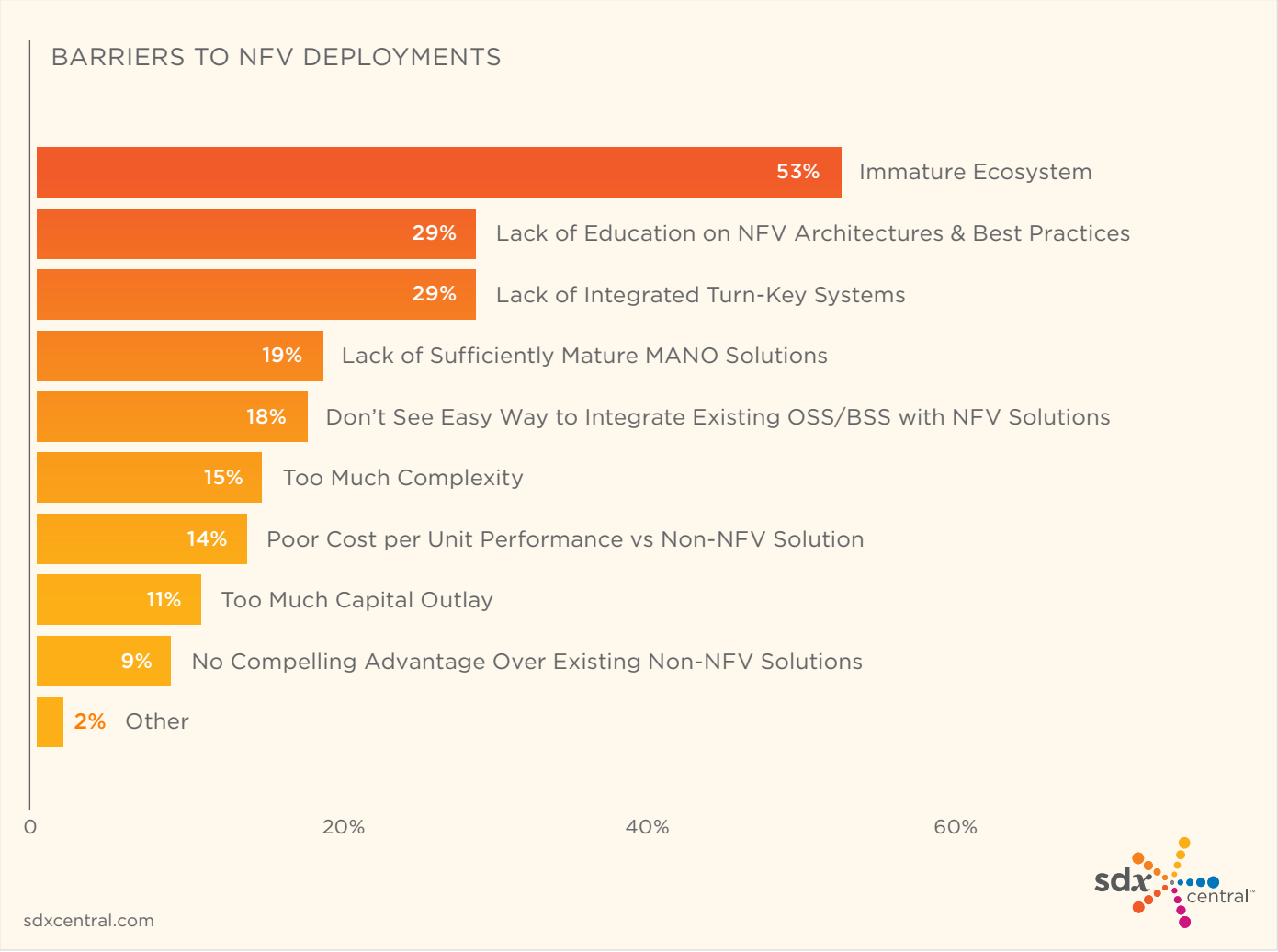
market summary

When probed further on the barriers to NFV deployment, respondents noted there were a variety of factors that are impeding the faster rollout of NFV. Fifty-three percent said the difficulty certifying and integrating multi-vendor solutions was a barrier, which speaks to the immaturity of the overall NFV ecosystem.



Twenty-nine percent of respondents said a lack of turn-key NFV integrated systems and general education on NFV architectures and best practices were hindering deployments, which also indicates how early the market still is. Interestingly, less than 10% of respondents (9% to be exact) felt they couldn't see a compelling advantage for NFV over existing solutions. This confirms the potential of the approach and should provide software vendors the incentive to continue to invest in developing standards and building out the capabilities of their services.

Conclusion: NFV Market Open for Business

Think of the many factors and characteristics we have cited: The relative immaturity of existing NFV solutions, the challenges of the OpenStack platform, the need for integration, and the lack of a path to end-to-end orchestration and integration with OSS. All of these factors lead us to a big conclusion: the field is still wide open.

Some of our survey data backs this up. No single vendor has yet emerged as a definitive leader. When asked to pick the top three major equipment or software vendors they felt had the most NFV mindshare, respondents to the SDxCentral survey were all over the place. Only Cisco received a majority of the vote, at 59%; Juniper

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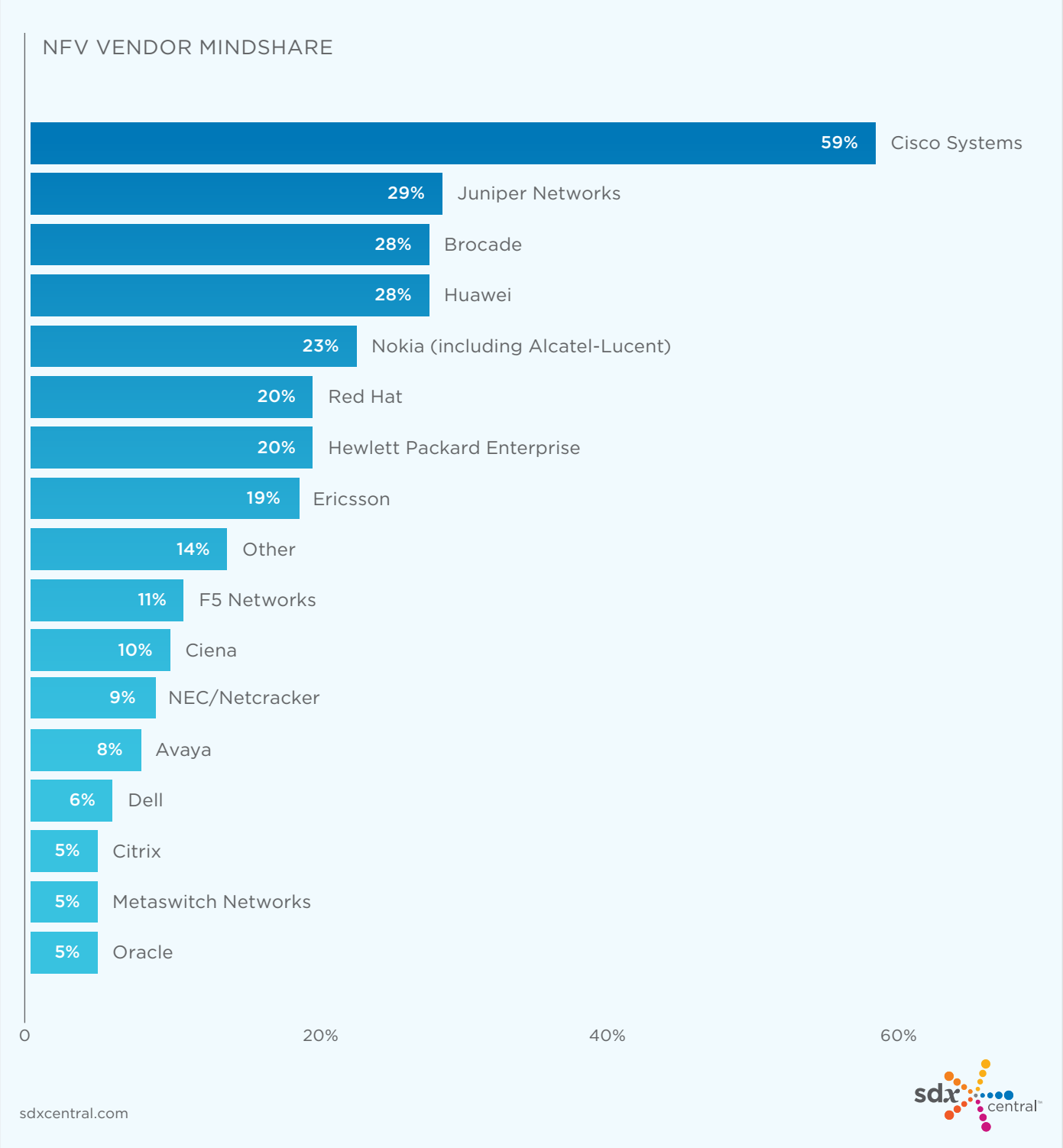
market summary

Networks received 29% of the vote, followed by Brocade and Huawei, who were each chosen as leaders by 28% of respondents. Nokia (including Alcatel-Lucent) and Hewlett Packard Enterprise were the only other vendors to receive more than a fifth of the vote, at 23% and 20% respectively.



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This data speaks to the market's maturity level – there is still a lot of opportunity for both established players and new entrants to make noise and gain share. We also think that it underplays some of the OSS and software-deep players, especially vendors such as Ericsson, HPE, NEC/Netcracker, and Oracle – all of which have large pieces of the software and OSS stack as well as integration capabilities.

The bottom line is that a ton of players are going after this market and the ones that put together the most cohesive and broad integration strategies will be the winners. Those vendors that can prove valuable integrators and "guides" to the new technology will be the most successful. The SDxCentral research team also believes that companies with strong software and OSS solutions will have a key advantage. New NFV technologies & components must be able to work with existing integrated environments, including OSS, billing, and other systems.

NFV MANO Products

The NFV MANO framework is comprised of orchestrators, VNFMs, and VIMs that control all of the computing, networking, storage, and virtual machine resources in an NFV data center. It is responsible for managing and maintaining the data repositories, reference points, and interfaces that are used to exchange information between all the components that make up the service to ensure the ongoing orchestration of the NFVI and VNFs.

In this section, we describe specific NFV MANO products from a collection of technology vendors.

The NFVO or orchestrator is in charge of orchestrating, managing and automating the end-to-end network service that is delivered by the VNF and NFVI. Typically there is a single orchestrator that oversees the realization of the NFV service.

The VNFM or VNF managers are responsible for the VNF lifecycle, including instantiation, updates, queries, scaling and termination. Multiple VNF managers can be deployed, depending on the environment a manager may be required for each VNF or may be in charge of several VNFs. There is active debate in the community around the current situation with each vendor driving their own VNF-Ms for managing VNFs. This can result in an explosion of multiple VNF-Ms in an NFV deployment, adding to management complexity and lack of consistency in VNF lifecycle management. Carriers are pushing back and driving vendors into supporting generic VNF-Ms (multi-vendor), allowing them to avoid a situation with a one-VNF, one-VNF-M pairing.

VIMs are used to control and manage the interaction of a VNF with the underlying computing, storage and network resources under its authority. VIMs are often a part of the virtualization layer, versus a separate solution, so the way an organization supports the virtualization layer (via hypervisor, OS or application) is likely going to be the way they support VIM functionality. VIMs provide visibility into the underlying infrastructure and handle resource management, including the:

- Inventory of resources available to the NFVI
- Allocation of virtualization enablers
- Ongoing management of infrastructure resources and allocation shifts to optimize utilization and efficiency

For the NFV MANO architecture to work properly and effectively, it must be integrated with open application program interfaces (APIs) in the existing systems. The MANO layer works with templates for standard VNFs, and gives users the power to pick and choose from existing NFVI resources to deploy their platform or element.

NFVI Products

NFVI is the hardware and software resources that make up the NFV environment, which can vary greatly from organization to organization, depending on the network's complexity and geographic distribution. This includes any network connectivity between data centers or clouds as well as the physical compute, storage and networking equipment that provides processing, storage and connectivity to VNFs through the virtualization layer. ETSI standards dictate that NFVI must secure, provide high availability, and support service level agreements.

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Other supporting services for NFV, such as service catalogs, external testing and external monitoring will likely be built into the NFVI over time, as they become a critical part of the infrastructure and are increasingly relied on to ensure the uptime and performance of the systems.

The virtualization layer sits right above the hardware and abstracts the resources, so they can be logically partitioned and provided to the VNF to perform their functions. (It decouples the VNF software from the underlying hardware, so the VNF can use the appropriate virtualized resources to execute its function.)

There isn't a specific solution required for an NFV deployment to work, rather the NFV architecture can leverage an existing virtualization layer, such as a hypervisor, with standard features that are simply capable of abstracting hardware resources and pointing to VNFs. When hypervisor support is not available, organizations often achieve the virtualization layer through an operating system (OS) that adds software on top of a non-virtualized server or by implementing the VNF as an application.

This product area is expanding rapidly as the NFVI is built out. As described in the "market landscape" sections, different vendors have different approaches to building the NFV Infrastructure, and very few vendors have all of the components. The industry ecosystem is being formed as vendors forge many partnerships, including leveraging open source components in their portfolio.

While many vendors claim they offer NFVI, their portfolios vary widely, making it difficult for network pros to make investment decisions. The good news is that the ETSI NFV Industry Specification Group has outlined a few basic elements that make an NFVI environment work.

Another interesting trend to watch is how some vendors are integrating NFVI components into their existing hardware and software portfolios to provide differentiation.

NFV Monitoring and Testing Products

Monitoring and testing of NFV environments is crucial to their success. Just as traditional networks must be tested, so do virtualized ones.

Testing and monitoring solutions can reveal the reliability and performance challenges of a virtual environment by measuring how traffic patterns and applications are impacting the infrastructure. These tools also validate performance, provide visibility into the network and process. Theses tools are essential to test and monitor network infrastructure, capacity, scalability, and convergence.

Some key reasons why testing and monitoring tools are key to this environment:

- NFV deployment can only be successful if they prove as reliable as existing implementations.
- Testing and monitoring of NFVI is a key component of any production roll-out
- Instrumentation within the NFVI is critical for ensuring appropriate use of resources, scaling of infrastructure based on load and identifying bottlenecks to efficient deployment within the system.
- Monitoring: identify hotspots, failures (so can remediate and recover), ensuring efficient use of NFVI – feed information to VNFM and NFVO to ensure scaling and failure recovery
- Testing is needed to understand performance characteristics of overall system and where performance tweaks might be needed.

Tools for the NFV market today can be used to validate protocol compliance and interoperability, test virtual environments, emulate network traffic or application, validate an installation, analyze traffic, and provide security.

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Vendor Profiles

The following sections profile many of the vendors in the NFV market. The individual profiles were created through a collaborative effort between SDNCentral's Research Team and the Vendor's product experts. SDNCentral worked under the assumption the information provided by the vendors was factual, auditing the submissions only to remove unverifiable claims and hyperbole. Extended profiles can **be viewed online**.

While every attempt has been made to validate the capabilities listed in the profiles, SDNCentral advises end users to verify the veracity of each claim for themselves in their actual deployment environments. SDNCentral cannot be held liable for unexpected operations, damages or incorrect operation due to any inaccuracies listed here. SDNCentral welcomes feedback and additional information from end users based on their real-world experiences with the products and technologies listed. The SDNCentral research team can be reached at **research@sdxcentral.com**.

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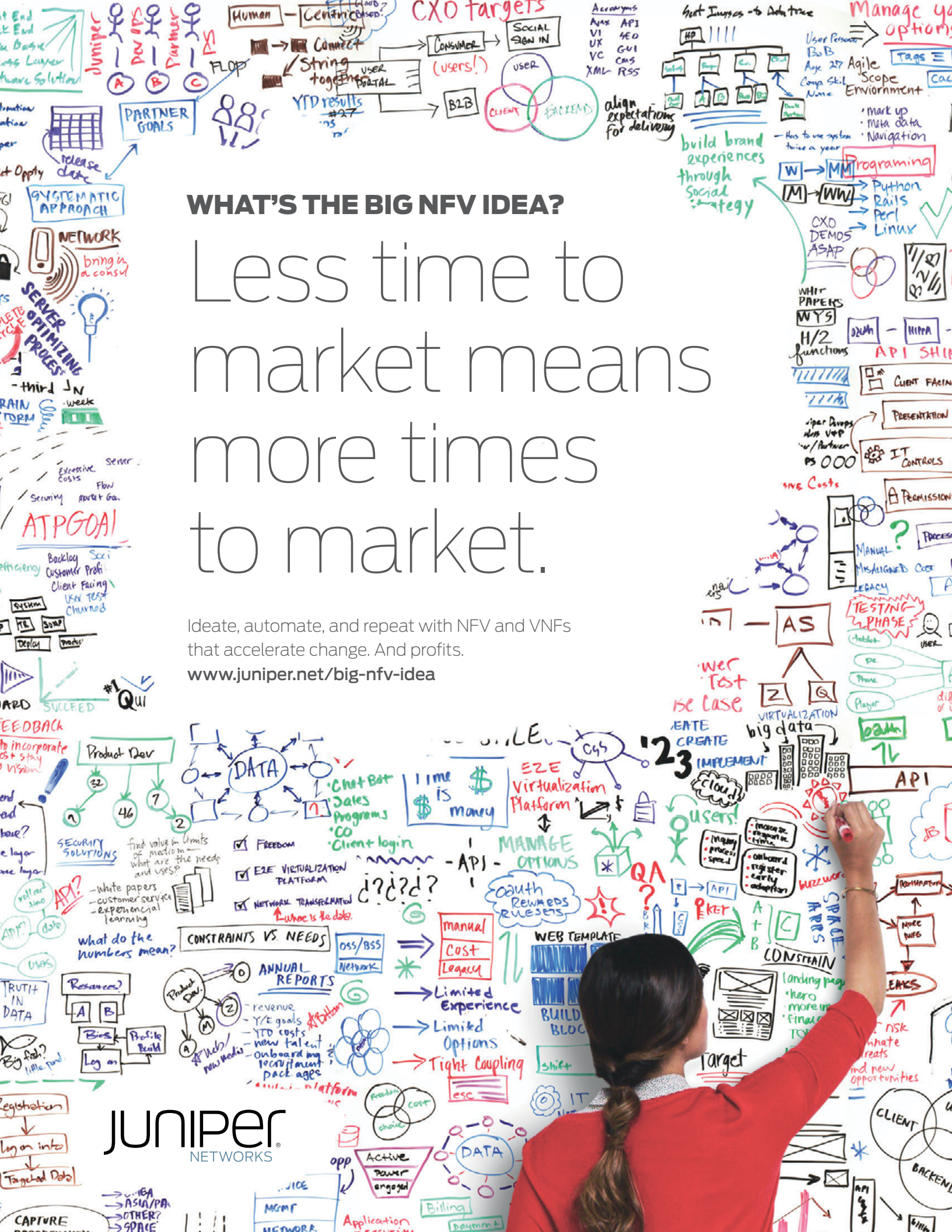
WHAT'S THE BIG NFV IDEA?
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www.juniper.net/big-nfv-idea
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www.windriver.com/titaniumserver

category: MANO

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BROCADE

130 Holger Way
San Jose, CA 95134
www.brocade.com
1.888.BROCADE

Brocade SDN Controller

(Click for Online Version)

www.brocade.com/en/products-services/software-networking/sdn-controllers-applications/sdn-controller.html

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager, OpenFlow management for underlying PNF. Netconf configuration management for VNF and PNF. Overlay Management for OVSDB.

Description: The Brocade SDN Controller is the first commercial and pure play distribution of the OpenDaylight Project with no proprietary extensions or platform dependencies. The Brocade SDN Controller is packaged to include tools and services to allow for customers to quickly deploy software-defined networks within their existing environments with confidence. The product is designed to interoperate with OpenDaylight-compatible 3rd-party switches and routers and supported by Brocade's support organization and its expert leaders within the OpenDaylight developer community. A crucial element of ETSI MANO architectures, the Brocade SDN Controller provides the interfaces for both physical and virtual functions for use within the MANO framework.

Uniqueness: The Brocade SDN Controller is a pure play packaged distribution of the OpenDaylight Project, continuously built with no proprietary extensions. The Brocade SDN Controller supports multi-vendor environments for both physical and virtual functions to be managed by the controller. Product options include both developer and commercial licenses with Premium levels of support utilizing the expertise of Brocades leadership within the open source community. Customers and partners also benefit from being to take advantage of application portability to and from different ODL-based controllers with the Brocade SDN Controller.

Supported Hypervisors
All supported by & supporting RHEL 7.1 or Ubuntu 14
Supported OS
Linux (RedHat Enterprise Linux 7.1 and Ubuntu 14.04)
Supported CMP
OpenStack, Ciena Blue Planet, ADVA Ensemble Orchestrator, Cloudify by Gigaspaces, Rift.Ware by Rift.io, Amdocs Network Cloud Service Orchestrator.
Supported HW Acceleration
Hardware based acceleration to increase throughput and scale is dependent on the underlying Guest/Host Operating System (RHEL or Ubuntu) the Brocade SDN Controller is installed. HW acceleration support will be dependent on the underlying Guest OS the SDN Controller is installed in. Support and configuration for techniques such as SR-IOV, PCI pass through and DPDK utilization will be dependent on the underlying OS to improve upon scale and performance.
Scalability and Performance
Inventory Performance: Maximum number of nodes and OpenFlow links. Flow Performance: Maximum number of flows per second through Northbound RESTCONF API.
Ecosystem Partners
Amdocs, ADVA, Coriant, Gigaspaces, Rift.io

Customer Use Case #1: Network Resources Optimization (NRO)
Dynamically optimizing the network based on load and state. This is the most common carrier use case as it optimizes the network using the near-real-time state of traffic, topology and equipment. NRO uses a variety of southbound protocols (for example, NETCONF, BGP-LS or OpenFlow) depending on the underlying network.
Customer Use Case #2: Visibility and Control
Centralized administration of the network and/or multiple controllers. This is sometimes used by carriers or enterprises as a precursor to NRO.
Customer Use Case #3: Automated Service Delivery for NFV
Agile service delivery on cloud infrastructure in either the enterprise or service provider environment. The underlay could be OpenStack, and in the carrier case will often also include Network Functions Virtualization (NFV). Additionally provide on-demand services that may be controlled by the end user or the service provider. Examples include bandwidth scheduling (either calendared or on-demand) or dynamic VPN services.
Product Datasheet
www.brocade.com/en/backend-content/pdf-page.html?/content/dam/common/documents/content-types/datasheet/brocade-sdn-controller-ds.pdf

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130 Holger Way
San Jose, CA 95134
www.brocade.com
1.888.BROCADE

Brocade Vyatta Network OS

(Click for Online Version)

www.sdxcentral.com/products/brocade-vyatta-network-os

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Software Platform with integrated hypervisor and native Layer 2 to Layer 4 networking

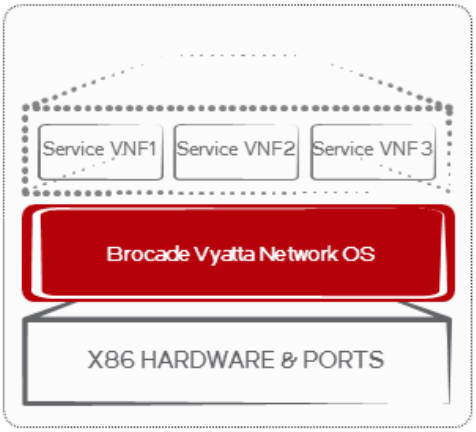
Description: Built for Network Functions Virtualization (NFV), the Brocade Vyatta Network Operating System (OS) is the industry leading high performance networking functions virtualization infrastructure (NFVI). Powering the Brocade vRouter, the Brocade Vyatta Network OS is enhanced and optimized to deliver integrated Layer 2 to Layer 4 networking functions with an embedded hypervisor for Service VNF hosting and delivery. It offers advanced routing, stateful firewall, and VPN capabilities in a high-performance software form factor with an accelerated vSwitch for optimal service function chaining. This platform utilizes innovative Brocade vPlane technology, enabling hardware-like routing performance in a software-based network form factor. Designed for situations in which high-performance virtual routing is required, the Brocade Vyatta Network OS can be used in numerous ways by being deployed as the underlying Host OS or as a VNF.

Uniqueness:

- The Brocade Vyatta Network OS provides a low virtual footprint with an efficient and optimized design. This provides for more head room for supporting Guest Service VNFs to monetize value added services.
- Efficient CPU resource utilization for performance of the OS and extending high performance capability to Guest Service VNFs through integrated accelerated vSwitch support.
- Integrated networking reducing VNFs, allowing for other value added network functions deployed as guests.
- Open Data modeling mimicking an operator's typical experience with network configuration
- Open approach supporting the use of 3rd party VNF vendors to support vCPE use case functionality.

Supported Hypervisors	
KVM. The Brocade Vyatta Network OS supports an integrated KVM based hypervisor.	
Supported OS	**Supported CMP**
The Brocade Vyatta Network Operating System is built upon Debian Linux with specific customizations and enhancements to be optimized for network control and forwarding.	The Brocade Vyatta Network OS supports any CMP that utilizes NETCONF/YANG models as the method for orchestration and instantiation of VNFs on the Brocade platform.
Supported HW Acceleration	
The Brocade solution leverages Intel DPDK for the creation of a high speed packet pipeline within the data plane. The Brocade Vyatta Network Operating System also has an embedded Accelerated vSwitch to extend the high speed packet pipeline to Guest VNFs hosted as other Service VNFs on the platform.	
Scalability and Performance	
• Line packet forwarding performance at all packet sizes on a single physical core for the data plane. • Linear performance scale on the data plane with additional allocation of CPU resources.	

Ecosystem Partners
Amdocs, ADVA, Ciena, Netcracker
Customer Use Case #1: Managed vCPE
Brocade Vyatta Network OS provides integrated network services with an integrated Hypervisor and accelerated v-switch to support hosting of other Service VNFs for a Branch vCPE solution. Operators can deploy VNFs such as WAN Optimization, Firewall, VPN and routing hosted by the Brocade Vyatta Network OS with embedded VNF service chaining and a NETCONF interface for Host and VNF life cycle management.



- NFVI with native networking
- Integrated Service chaining
- High resource efficiency and headroom for services

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FEATURED

CISCO SYSTEMS, INC.

170 West Tasman Drive
San Jose, California 95134
800.553.6387
www.cisco.com

OPNFV: Y **ETSI NFV ISG:** Y

Cisco NFV Infrastructure

(Click for Online Version)

www.cisco.com/go/nfvi

Product Category: Infrastructure
Sub-Category: NFV HW platform, NFV SW platform, VIM, HW acceleration, SW acceleration, Element Management System, value-added SW tools.
Description: Cisco NFV Infrastructure fully integrates Red Hat Enterprise Linux, OpenStack Platform, and CEPH (for reliable storage) to run on our Unified Computing System. Cisco is your single point of support.
Uniqueness: Cisco NFV Infrastructure – integrated, optimized, and verified – lowers TCO with a platform ready to deploy VNFs from any vendor. Its unique SW tools automate and validate OpenStack installation. Its carrier-grade availability and performance ensure SLAs.

Supported Hypervisors	Supported CMP
KVM	OpenStack

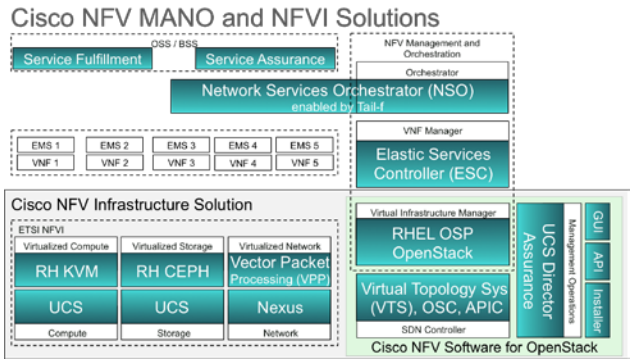
Cisco Virtual Topology System (VTS)

(Click for Online Version)

www.cisco.com/go/vts

Product Category: MANO
Sub-Category: SDN SW overlay provisioning and management system
Description: Open, standards-based Cisco VTS automates DC network fabric provisioning for virtual and physical infrastructure.
Uniqueness: Supports multiple tenants on a common infrastructure with on-demand SW overlay networks.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD, Cisco Network Services Orchestrator
Supported OS	
Linux (multiple)	



Cisco Network Services Orchestrator (NSO) enabled by Tail-f

(Click for Online Version)

www.cisco.com/go/nso

Product Category: MANO
Sub-Category: Orchestration
Description: Cisco NSO provides the simplicity and automation to deliver more differentiated and competitive services faster. Create and change services easily with NSO using standardized models.
Uniqueness: Automates your multivendor physical and virtual devices with ready-made models for dozens of vendors. Reduces coding up to 90% using standardized YANG models. Makes precise changes with atomic transaction control.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD, Cisco Elastic Services Controller
Supported OS	
Linux (multiple)	

Cisco Elastic Services Controller (ESC)

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www.cisco.com/c/en/us/products/collateral/cloud-systems-management/network-services-orchestrator/datasheet-c78-734670.html

Product Category: MANO
Sub-Category: Orchestration, VNF Manager, VIM
Description: Cisco ESC provides agentless lifecycle management for VNFs from any vendor and works with multiple VIMs. It dynamically provisions and scales VNFs, individually or in groups, in a multitenant DC.
Uniqueness: Delivers NFV's promised speed and efficiency by automating the entire VNF lifecycle, including VNF recovery, advertisements, smart licensing, and elastic scaling.

Supported Hypervisors	Supported CMP
ESXi, KVM, Cisco NFVIS (includes KVM)	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	
Linux (multiple)	

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FEATURED

category: MANO

JUNIPER NETWORKS, INC.

1133 Innovation Way
Sunnyvale, CA 94089
www.juniper.net
contrail-info@juniper.net

Juniper Networks Contrail

(Click for Online Version)

www.juniper.net/us/en/products-services/sdn/contrail

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

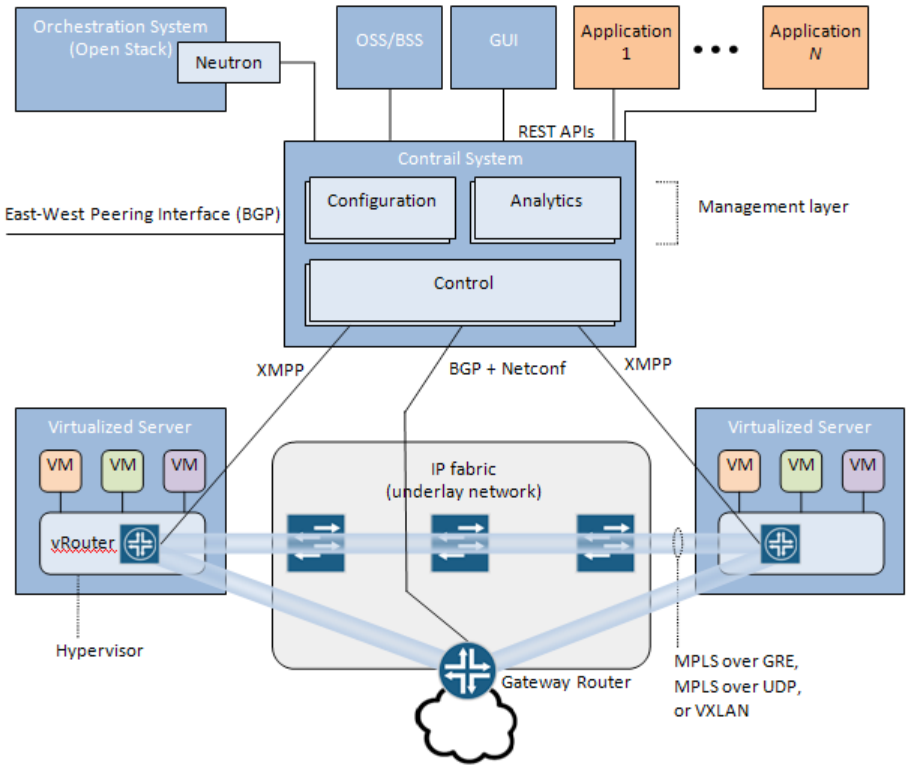
Description: Juniper's Contrail is a simple, open, and agile software defined networking solution that automates and orchestrates the creation of highly scalable virtual networks. These virtual networks let you harness the power of the cloud – for new services, increased business agility, and revenue growth.

- **SIMPLE:** Creates virtual networks that integrate seamlessly with existing physical networks, and that are easy to manage and orchestrate.
- **OPEN:** Avoids expensive vendor-lock with an open architecture that interoperates with a wide range hypervisors, orchestration systems, and physical networks.
- **AGILE:** Speeds time to market for new services by automating the creation of virtual networks that interconnect private, hybrid, and public clouds.

Service providers can use Contrail to enable a range of innovative new services, including cloud-based offerings and virtualized managed services. For enterprises, Contrail can increase business agility by enabling the migration of applications and IT resources to more flexible private or hybrid cloud environments.

Uniqueness: Based on the principles of SDN, Contrail leverages BGP signaled end-system IP/VPNs to implement network virtualization overlays. These standards based overlays, which span cloud boundaries, deliver a vendor-neutral approach for creating multitenant virtualized, containerized and bare-metal cloud environments. Infrastructure analytics and visualization features provide insight into virtual and physical networks, simplifying operations and decision making with proactive planning and predictive diagnostic capabilities.

1. Contrail Networking provides the ability to weave virtual overlay networks with heterogeneous environments that straddle public and private clouds, orchestration tools and compute workload vehicles.
2. Contrail Networking allows tenants to specify traffic selection criteria and the network function sequences that selected traffic will be subjected to – in other words, Service Function Chaining.
3. Contrail Service Orchestration is a comprehensive management and orchestration platform that delivers virtualized network services built on an open framework. By allowing service providers to selectively centralize or distribute the service creation process, Contrail Service Orchestration addresses the



Contrail Architecture

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needs of small to midsize businesses as well as large enterprises with a single and elegant point-and-click interface. Product managers get a clean and polished service design experience; service management and troubleshooting are streamlined for administrators; and customers have a personalized self-service portal to select the services that best meet their evolving business requirements.

Supported Hypervisors	Supported OS
ESXi, KVM, Hyper-V	Linux (Ubuntu, CentOS)

Supported CMP

OpenStack, VMware vRealize/vCAC/vCD, Kubernetes

POCs Delivered

Service Chaining for NW Function Selection in Carrier Networks In the POC environment, network functions are integrated into cloud servers as VNFs, where each user can individually select and apply thier intended network functions. Also it is expected that administrators are able to add, delete or migrate VNFs at any time. In our PoC we will demonstrate several use cases of Service Chaining with our method.

Scalability and Performance

Please visit: www.opencontrail.org/evaluating-opencontrail-virtual-router-performance

Customers

NTT Innovation Institute Inc. (NTT i3), Orange Business Solutions (OBS), Symantec, CloudWatt, Lithium Technologies
www.juniper.net/us/en/products-services/sdn/contrail
www.juniper.net/us/en/solutions/nfv/#

Ecosystem Partners

www.juniper.net/us/en/partners/technology-alliances/data-center

Pricing and License Model

Please contact Juniper Networks at contrail-info@juniper.net for pricing information.

Customer Use Case #1: Cloud CPE

The ability to innovate managed CPE services is inhibited by a closed proprietary platform that restricts scalability and requires up-front CapEx. Deployment is a time-consuming and manual process that does not align with the dynamic market requirements of today's enterprises. Juniper automates service delivery with the only scalable Cloud CPE solution. Based on Juniper's end-to-end scalable NFV capabilities, the Cloud CPE solution enables flexible service creation with a multi-deployment model that incorporates an open framework for third-party VNFs to accelerate service delivery. www.juniper.net/us/en/solutions/nfv/cloudcpe

Customer Use Case #2: VNF Marketplace (Service Chaining)

Juniper's Contrail supports chaining of various Layer 2 through Layer 7 services such as firewall, NAT, IDP, and so on. Services are offered by instantiating service virtual machines to dynamically apply single or multiple services to virtual machine (VM) traffic. It is also possible to chain physical appliance-based services. By service chaining, the Contrail software creates tunnels across the underlay network that span through all services in the chain.
www.juniper.net/techpubs/en_US/contrail2.2/topics/task/configuration/service-chaining-vnc.html

Customer Use Case #3: TELCO Cloud

Traditional methods for constructing network infrastructure – centralized network functions delivered as physical appliances – are inhibiting service providers' ability to grow cost effectively and react quickly to changing market, customer, and network requirements. Juniper Networks NFV solution features Contrail Cloud as a turnkey platform for building open, automated, service-ready Telco clouds leveraging industry leading virtual network functions and programmable NFV Infrastructure (NFVI). Combined with our Our MetaFabric™ architecture defines a blueprint for building agile, intelligent cloud data centers that serve as a foundation for rapid service delivery. Combine security, analytics, and automation with Juniper switching and routing innovation, and you have a powerful solution to simplify complex service delivery and network operations.
www.juniper.net/us/en/solutions/nfv/telco-cloud/#

Product Data Sheets

1) Contrail Networking: www.juniper.net/assets/us/en/local/pdf/datasheets/1000521-en.pdf
2) Contrail Service Orchestration: www.juniper.net/assets/us/en/local/pdf/datasheets/1000559-en.pdf

Additional Information

www.opencontrail.org/opencontrail-architecture-documentation/#section2

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WIND RIVER

500 Wind River Way
Alameda, CA 94501
www.windriver.com
510.748.4100

Titanium Server

(Click for Online Version)

www.windriver.com/products/product-overviews/Titanium-Server-Product-Overview-TiS

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Software Platform

Description: Enterprise server and computing technologies were not designed for the rigorous demands of the carrier network. Titanium Server solves that problem by providing an application-ready software platform that runs virtual functions with carrier grade reliability and is built to support the intensive performance, reliability, and security requirements of the world's most demanding computing and communications networks.

Uniqueness: Titanium Server provides and application-ready software platform that runs virtual functions with carrier grade reliability and is built to support intensive performance, reliability and security requirements of the worlds most demanding computing and communications networks. Titanium server gives you the flexibility to scale your services up, down, in, and out – rapidly, deploying new services dynamically, when and where they are needed. It also delivers The performance to maximize the number of subscribers you support on each server, so you minimize your operating costs and The reliability you need to keep your services up – always.

Supported Hypervisors	Supported CMP
KVM	OpenStack

Supported OS

Linux (Any Guest OS)

Supported HW Acceleration

Titanium Server supports each of DPDK, PCI pass-through and SR-IOV. Advanced H/W acceleration devices such as the Intel® Communications Chipset 89xx (e.g. Coleto Creek) are directly assignable to VNFs using SR-IOV. This is managed directly in the Titanium Server GUI.

Scalability and Performance

- 99.9999% uptime guaranteed
- Live migration with less than 200 milliseconds
- Accelerated Virtual Switch up to 40x faster than OVS

Ecosystem Partners

ADVA, Brocade, Genband, HPE, Huawei

Customers

Altiostar: www.windriver.com/customers/customer-success/network-equipment/altiostar
Raisecom: www.windriver.com/customers/customer-success/network-equipment/raisecom

Customer Use Case #1: Virtual Business CPE

By leveraging the Titanium Server CPE platform, service providers can deploy cost-sensitive NFV applications such as a virtual business CPE (vBCPE) on only two servers. Each server runs the full set of carrier grade compute, control, and storage functions, while working to deliver best-in-class virtual network function (VNF) performance to maximize the number of users supported per server and thereby also maximize OPEX savings. At the same time, Titanium Server CPE helps service providers to maintain full carrier grade uptime for their vBCPE services, which enables them to minimize any revenue impact resulting from Service Level Agreement (SLA) penalties triggered by service downtime.

Customer Use Case #2: C-RAN Solution for NFV Deployment

Wind River, in collaboration with China Mobile, has developed a C-RAN solution for NFV deployment. The joint solution delivers a live demonstration of a successful C-RAN that provides near-native hardware performance and live migration of L1 to L3, and that follows the requirements of the ETSI NFV Industry Standards Group.

Customer Use Case #3: Carrier Grade Virtual Evolved Packet Data Gateway (ePDG)

We have collaborated with GENBAND and HP Enterprise to demonstrate differentiated NFV capabilities. GENBAND's virtualized evolved Packet Data Gateway (ePDG) and NFV Cloud Manager software will be integrated onto the HPE Helion Open Stack carrier-grade NFV platform ("Carrier grade" supplied by Wind River) to demonstrate LTE Wi-Fi capabilities.

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Ensemble Orchestrator

(Click for online version)

www.advaoptical.com/~/media/Resources/Data%20Sheets/Ensemble_Orchestrator.ashx

ADVA OPTICAL NETWORKING

www.advaoptical.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager

Description: Ensemble Orchestrator is an ETSI MANO-compliant NFV management and orchestration solution that provides end-to-end VNF and network-service-lifecycle management. The Ensemble Orchestrator handles VNF onboarding, network service design, service deployment and service operations and management.

Uniqueness: Open Interfaces, Multi-Cloud Services, Advanced User Tenancy Model, VNF-Agnostic NFV-Orchestrator and VNF-Manager with a large partner ecosystem.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (CentOS 6, version 6.7)	DartPoints

Affirmed Mobile Content Cloud

(Click for online version)

www.affirmednetworks.com/wp-content/uploads/2015/07/TCO-Report_7.13.15_ACG-Template.pdf

AFFIRMED NETWORKS

www.affirmednetworks.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration

Description: The Affirmed Mobile Content Cloud is a flexible, scalable, carrier-class virtualized software architecture that provides multiple industry leading innovations, including the Affirmed Open Workflow. The Affirmed Mobile Content Cloud operates on the company's AN3000 off-the-shelf platform and on numerous industry-leading computing platforms, such as its partners' blade servers.

Uniqueness: Dynamic capacity scaling: Scale in or out traffic capacity based on traffic demands. Virtualized network infrastructure can also reduce operating expenses due to centralized management and orchestration (MANO). Geo-independence: Pool network resources centrally and provision dynamically across geographies to reduce under/over capacity in certain regions. Clustered architecture : Consolidating the EPC functions into a cluster.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD, CloudStack
Supported OS	**Customers**
Linux (Redhat Linux Openstack)	ATT Domain 2.0 Partner, Telus, Vodafone, LGU+

Chameleon SDS

(Click for online version)

www.amartus.com/files/UserFiles/file/ChameleonSDS%20Datasheet_FINAL.pdf

AMARTUS

www.amartus.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration

Description: Chameleon SDS provides MEF-based metro carrier Ethernet services and supports any other network services, including IP / MPLS, MPLS-TP, and optical transport.

Uniqueness: The Chameleon SDS uses a meta-model driven architecture to make the platform completely customizable and extensible on the fly. No code has to be written. Furthermore a RESTful API with prebuilt protocol libraries allows for support for pretty much any need.

Supported Hypervisors	Supported CMP
ESXi, KVM, Any	OpenStack
Supported OS	**Customers**
Linux (Any Linux OS that supports J2EE), Windows (Any Windows version that supports J2EE)	Not Provided

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Anuta Network NCX (Click for online version)

www.anutanetworks.com/wp-content/uploads/2015/06/NCX-Datasheet.pdf

ANUTA NETWORKS, INC

www.anutanetworks.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager

Description: NCX Enterprise is designed to deliver SDN benefits for medium to large enterprise campus, branch, retail, and data center networks by leveraging both physical and virtual devices across multi-vendor network infrastructures. Anuta NCX delivers complete network service orchestration for campus, branch, and data center networks.

Uniqueness: Anuta NCX delivers YANG model driven network service orchestration for existing multi-vendor physical and virtual infrastructure and supports all the use cases.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
NCX is delivered as Virtual Appliance and it can be deployed by any hypervisor including VMware, KVM and Hyper-V.	www.anutanetworks.com/customers

Athena

(Click for online version)

ATTO RESEARCH

www.atto-research.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

Description: Athena DMZ solution can be easily connected to a variety of services and it has flexible ACA architecture so it is possible for physical, logical expansion and change from service continuity status. Athena complies with ETSI NFV standard architecture and uses OpenStack infra verified in the various fields.

Uniqueness: Convergence of previous VNF and SDN technology which applied to various traffic control techniques enables to manage VNF quickly between traffic flow so it eventually guarantees optimized convergence and performance. Compared to previous fixed DMZ solution, it is possible to change configuration according to the intention of the operator. Service chaining technology is applied so configuration of various securities and network services can be changed depending on cases.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Ubuntu 14.04, CentOS 7)	Not Provided

Avaya SDN Fx Architecture

(Click for online version)

www.avaya.com/usa/product/sdn-fx-architecture

AVAYA INC.

www.avaya.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration, Virtualized Infrastructure Manager

Description: The network handles once-manual functions automatically – for IT, this means less worry about connections and configurations and more focus on strategic applications. Avaya makes it possible with SDN Fx Architecture. The SDN design delivers a simpler, more agile network with an automated core, an open ecosystem, an enabled edge.

Uniqueness: Avaya SDN Fx is an architecture built on Avaya Fabric Connect, Fabric Extend, Fabric Attach, Fabric Orchestrator, Open Networking Adapter along with OpenDayLight, OpenFlow and OpenStack integrations. Avaya Fabric Connect is a standards-based network virtualization technology based on an enhanced implementation of IEEE 802.1aq Shortest Path Bridging and IETF RFC 6329.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V, Xen	OpenStack
Supported OS	**Customers**
Linux, Windows	www.avaya.com/usa/case-studies/find-case-study/?

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Brocade VNF Manager (Click for online version)

www.sdxcentral.com/products/brocade-vnf-manager

BROCADE

www.brocade.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: VNF Manager

Description: Brocade VNF Manager is a new Orchestration application based on the OpenStack "Tacker" Project. It addresses NFV Orchestration and VNF Manager use-cases using standards based architectures. It serves as a generic VNF manager that supports basic life-cycle management of VNFs, Health monitoring and implements Closed loop healing actions. This application is layered on top of Brocade SDN controller 3.x to integrate the orchestration and control aspects found in typical NFV/SDN deployments.

Uniqueness: Brocade VNF Manager is a pure play open source approach for the OpenStack project – Tacker. Customers are offered a complete set of developer & professional support programs & services to ensure optimal experience.

Supported Hypervisors	Supported CMP
KVM, Support for managing of VNFs installed on the Brocade Vyatta Network OS for vCPE solutions.	OpenStack, Ciena Blue Planet, ADVA Ensemble Orchestrator, Cloudify by Gigaspaces, Rift.Ware by Rift.io, Amdocs Network Cloud Service Orchestrator
Supported OS	
Linux (RedHat Enterprise Linux 7.1 and Ubuntu 14.04)	

Ubuntu OpenStack

(Click for online version)

http://insights.ubuntu.com/wp-content/uploads/Canonical_Distribution_Factsheet_Web.pdf

CANONICAL

www.canonical.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Virtualized Infrastructure Manager

Description: Ubuntu is a popular operating system for OpenStack. It provides a fast, reliable way to build an enterprise-scale cloud, from provisioning to deployment and management.

Uniqueness: The Canonical Distribution of Ubuntu OpenStack is the fastest and easiest way to build an OpenStack cloud. It includes automation via a web-based UI, a choice of components for hypervisor, storage, and networking. Management is also included from the same UI. The Landscape Autopilot product is the UI that allows for dashboard and deployment of resources. Juju is an orchestration tool that is included for deployment and distribution of workloads and MAAS is included for the provisioning of bare metal resources. In addition, professional support is available.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V, LXD	OpenStack
Supported OS	**Customers**
Linux (Ubuntu Server)	www.ubuntu.com/cloud/openstack

CA Virtual Network Assurance

(Click for online version)

www.ca.com/content/dam/ca/us/files/data-sheet/ca-virtual-network-assurance.pdf

CA TECHNOLOGIES

www.ca.com/us.html

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

Description: CA Virtual Network Assurance bridges infrastructure management capabilities to meet the needs of software-defined networking (SDN) and network functions virtualization (NFV) network velocity, reducing the complexity in network visibility and planning while improving self–service and automation.

Uniqueness: Overlay/underlay correlation; dynamic multi-layer relationship tracking; service chain building block views of network health.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack
Supported OS	**Customers**
Linux (CentOS, Ubuntu)	Not provided

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Exanova Service Intelligence

(Click for online version)

https://cenx.com/wp-content/uploads/2016/01/CENX-Exanova-DataSheet-20160113-ForWeb2.pdf

CENX, INC

www.cenx.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Service Assurance; related to TRAM (reference: Draft ETSI GS NFV-REL004 V0.2.0 [2016-01])

Description: Exanova Service Intelligence delivers real-time network analytics to drive data service agility and quality. It optimizes the delivery and management of differentiated services, such as reliable IoT connectivity, on-demand enterprise access to the cloud, and dynamically scalable IaaS offerings.

Uniqueness: Exanova Service Intelligence brings big data analytics and hyperscale computing to networking, accelerating end-to-end service assurance and network operations. An analytics engine continuously ingests network data from multi-vendor systems to build and maintain a unified, trusted information model of services and network topology, which is fully visualized.

Supported CMP	
OpenStack, VMware vRealize/vCAC/vCD, VIO	
Supported Hypervisors	**Supported OS**
ESXi, KVM	Linux (RedHat and CentOS, versions 6 & 7)

Blue Planet (Click for online version)

media.ciena.com/documents/BP_Blue_Planet_DS.pdf

CIENA

www.ciena.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration

Description: Blue Planet is a scalable multi-layer SDN system with open APIs that enables rapid service deployment and application development in a multi-vendor network environment. Blue Planet enables network virtualization and management across various network layers, including fiber, DWDM, OTN and the services layer.

Uniqueness: Blue Planet is extensible to support Multi-Domain Service Orchestration (MDSO) capabilities to automate and manage service chains comprised of physical network elements and SDN/NFV-enabled virtual components across multiple domains (WAN, Cloud, NFV). Blue Planet provides DevOps-style self-service programmability allowing network operators to simplify the processes associated with on-boarding physical and virtual devices/functions.

Supported Hypervisors	**Supported CMP**
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	
Linux (Standard OpenStack bundle, validated with Red Hat, Wind River, and Ubuntu)	

Ericsson Network Manager & Ericsson Cloud Manager (Click for online version)

www.ericsson.com/us/ourportfolio/products/network-manager

www.ericsson.com/us/ourportfolio/products/cloud-manager

ERICSSON

www.ericsson.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager

Description: Ericsson Network Manager & Ericsson Cloud Manager provide VNFM and orchestration capabilities as defined in MANO. Ericsson Network Manager & Ericsson Cloud Manager are part of several of the vEPC and vIMS POC's. We have around 70 plus ongoing vEPC and vIMS POC's.

Uniqueness: Ericsson Network manager is a unified multi-layer, multi-domain (NFV, SDN, radio, transport & core) management systems and provides various functions such as VNFM, VNF application & network slice orchestration and network analytics. Ericsson Cloud manager does the cloud infrastructure management and NFVO part of MANO.

Supported Hypervisors	**Supported CMP**
ESXi, KVM, Hyper-V	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	
Linux	

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Virtuora Service Orchestrator

(Click for online version)

FUJITSU

www.fujitsu.com/global

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager

Description: Virtuora Service Orchestrator provides service design and lifecycle management that delivers dynamic service chaining for virtual and physical network functions. This simplifies the lifecycle management of VNF resources by creating a custom environment that easily integrates into a service provider's existing and evolving ecosystem. New VNFs and services can be rapidly deployed without constant churn on processes and frequent OSS integration efforts.

Uniqueness: Virtuora Service Orchestrator enables Agile Services with Carrier-grade Delivery, helping service providers simplify service chaining and troubleshooting; reduce OSS integration costs, and ensure consistency and resilience.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Red Hat Enterprise Linux version 7.1)	Not provided

Huawei FusionSphere

(Click for online version)

http://e.huawei.com/en/products/cloud-computing-dc/cloud-computing/fusionsphere/fusionsphere

HUAWEI

www.huawei.com/en

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

Description: Huawei's FusionSphere OS integrates the FusionCompute virtualization platform and FusionManager cloud management software. As a result, a wide range of enterprises can horizontally consolidate physical and virtual resources in data centers and vertically optimize the service platform.

Uniqueness: Huawei's FusionSphere is designed for ICT convergence. It is intended to provide a broad platform for telecom operators to smoothly transform traditional IT and telecom services to cloud platforms.

Supported Hypervisors	
Huawei UVP Virtualization Hypervisor. Huawei also claims to support 'third party' hypervisors with FusionManager.	
Supported OS	**Supported CMP**
Linux, Windows, FusionSphere is Huawei's own Cloud OS	OpenStack, Huawei FusionSphere integrates with OpenStack architecture.

MRV Pro-Vision

(Click for online version)

www.mrv.com/sites/default/files/brochures/us_pdfs/pro-vision_brochure.3.pdf

MRV COMMUNICATIONS

www.mrv.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration

Description: MRV's Pro-Vision is a carrier-class multi-layer service provisioning and management solution providing service visibility, intelligence and control. Pro-Vision provides real-time insights into higher layers that identifies applications, usage and trends and enables revenue generating services business models for service providers to differentiate and increase revenues.

Uniqueness: Pro-Vision provides complete L2/L3 packet-optical orchestration. A short list of features includes: zero-touch configuration, end-to-end carrier Ethernet service provisioning, real-time performance monitoring, SLA reporting and analytics, customer web portals, optical transport service management.

Supported Hypervisors	Supported CMP
KVM	KVM
Supported OS	**Customers**
Linux (Fedora Core 17, Redhat Enterprise Linux 5.0 (32- bit and 64-bit))	www.mrv.com/resources/case-studies

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NI-CONTROLLER

(Click for online version)

http://nakinasystems.com/wp-content/uploads/downloads/2015/01/Controller_Data_Audit_Discovery_Analytics_DS-ver1.0.pdf

NAKINA SYSTEMS

www.nakinasystems.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration

Description: NI-CONTROLLER automates audit and analysis of all parameters in physical and virtual networks. NI-CONTROLLER extracts real-time parameter settings and performs Data Integrity Analysis to gold-standards, identifying mismatches to help prevent service degradations and process inefficiencies.

Uniqueness: Ni-Controller is a part of a larger NI-Framework from Nakina that provides several types of orchestration capabilities and services. NI-Controller has proven scale to help customers audit numerous parameters.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD, CloudStack
Supported OS	**Customers**
Linux	AT&T, TimeWarner Cable, and Telcel/America Movil.

NI-FRAMEWORK

(Click for online version)

https://nakinasystems.com/resource-center/datasheets

NAKINA SYSTEMS

www.nakinasystems.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration

Description: NI-FRAMEWORK is an open, modular, and scalable software platform that provides mediation and abstraction between OSS, orchestration systems and network functions. NI-FRAMEWORK extends Management and Orchestration capability to any network, seamlessly bridging hybrid physical and virtual environments. It extends manageability to NFV Infrastructure, ensuring that the underlying NFVI is part of a holistic Management and Orchestration Strategy.

Uniqueness: The NI-FRAMEWORK provides proven integration with leading 3rd party management systems. It has an open translation mediation and abstraction layer via Apis to support existing interfaces or emerging ones.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux	BMC Software, Ericsson, HPE, IBM, Nokia, RSA.

NEC/Netcracker Orchestration

(Click for online version)

www.netcracker.com/products/products/orchestration

NEC/NETCRACKER

www.nec.com
www.netcracker.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

Description: The NEC/Netcracker Orchestration solution combines NEC's and Netcracker's deep-rooted networking and IT expertise and supports large-scale, unique systems integration capabilities.

Uniqueness: Solution is based on 20+ years of experience in OSS solutions development and implementation best practices. It is built on an open, carrier-grade platform that provides high availability, performance, and scalability critical when managing hybrid networks. We can support traditional networks, SDN/NFV networks and Private/Public Clouds with the same solution and it supports multivendor VNFs, PNFs, SDN controllers, and Virtual Infrastructure Managers.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vCenter
Supported OS	**Customers**
Linux	NTT Docomo (for NEC/ Netcracker)

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CloudBand

(Click for online version)

https://resources.alcatel-lucent.com/asset/187689

NOKIA

https://networks.nokia.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager, Network service orchestrator

Description: Nokia CloudBand (formerly Alcatel-Lucent CloudBand) helps service providers deliver a better class of cloud services. This solution lets service providers use their network assets to move beyond today's centralized and transaction-based service offers.

Uniqueness: Field proven openness: modular architecture; NFV infrastructure from different vendors; based on open source with active contributions from Nokia. Extensive onboarding experience with Nokia VNFs, CloudBand Ecosystem VNFs and VNFs from other network equipment vendors. Designed for lean NFV operations: Easy-to-deploy, pre-integrated, production ready NFV platform.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux	LGU+, VF Italy, Wind Mobile Canada

Network Service Orchestration Solution

(Click for online version)

www.oracle.com/us/industries/communications/network-service-orchestration-ds-2412291.pdf

ORACLE COMMUNICATIONS

www.oracle.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Orchestration

Description: Orchestrate and optimize your NFV Deployment. Accelerate network service agility with the rapid introduction, elastic scaling, and lifecycle management of network services containing multiple virtualized network functions.

Uniqueness: Flexible, product-based network service orchestration solution. Supports the orchestration of both virtualized & physical network functions. Supports fulfillment and assurance of customer orders on virtual networks enabling seamless extension of Oracle's Agile OSS into hybrid / virtual networks. Orchestrates hybrid / virtual networks such as vIMS supporting contemporary services such as VoLTE, VoWiFi, etc. through pre-integration with Oracle Application Orchestrator (VNFM) – for "dynamic" network operations.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux	Bell Canada

PLUMgrid OpenStack Networking Suite

(Click for online version)

www.plumgrid.com/wp-content/uploads/documents/PLUMgrid_ONS_For_OpenStack.pdf

PLUMGRID

www.plumgrid.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration, VNF Manager, Virtualized Infrastructure Manager

Description: A secure, comprehensive, and open software-only solution that delivers terabits of performance and scales across tens of thousands of workloads. Built on PLUMgrid Platform and IO Visor, it provides highly automated workflows that significantly reduce the deployment time of OpenStack clouds and enables users to create private Virtual Domains for applications and projects.

Uniqueness: PLUMgrid ONS offers the broadest support for OpenStack distros and installers including Huawei Compass, Mirantis OpenStack, Rackspace Private Cloud, RDO, Red Hat OpenStack Platform, and Ubuntu OpenStack. The newest release, PLUMgrid ONS 4.0, has also achieved Red Hat certification with Red Hat Enterprise Linux OpenStack Platform 7.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack
Supported OS	**Customers**
Linux	www.plumgrid.com/resources/testimonials

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category: MANO

CloudShell

(Click for online version)

www.qualisystems.com/products/cloudshell/architecture

QUALISYSTEMS

www.qualisystems.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Orchestration, Virtualized Infrastructure Manager

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

Uniqueness: CloudShell is a cloud sandboxing platform that allows modeling of NFV service deployments at both the NFV application (orchestration) level as well as the underlying service/infrastructure blueprints. This allows cloud sandbox blueprints to be created during the NFV product innovation phase, certification, and testing as providers validate architectures and vendors.

Supported CMP	
OpenStack, VMware vRealize/vCAC/vCD	
Supported Hypervisors	**Supported OS**
ESXi, KVM	Linux (All), Windows (All)

ETX-2i vCPE Platform

(Click for online version)

www.rad.com/template.MEDIA_ITEM/35726_RADview.pdf

RAD

www.rad.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration, Virtualized Infrastructure Manager

Description: The ETX-2i offers advanced L2 and L3 demarcation for SLA-based Ethernet business services, wholesale services and mobile backhaul.

Uniqueness: RAD's flexible vCPE offering supports virtualization at the customer edge and in the network and includes virtualization devices, physical CPE (pCPE) devices, pluggable devices to enhance server functionality and performance, and MANO for the network edge. It's enriched by the RAD D-NFV Alliance of NFV vendors and international system integrators. Key elements are the ETX-2i, a powerful IP and Carrier Ethernet NID/NTU with a field pluggable x86 D-NFV module for hosting VNFs, the RADview D-NFV Orchestrator for the network edge domain and the miniature MiNID for enhancing white box solutions with a powerful FPGA based NID function.

Supported Hypervisors	**Supported CMP**
KVM	OpenStack
Supported OS	**Customers**
VXworks	Not Provided

CloudMetro 100

(Click for online version)

www.telco.com/index.php?page=download&file=A133&ref=69&src=&filename=CloudMetro100_A4.pdf&filetype=Data+Sheets&product=CloudMetro%E2%84%A2+100

TELCO SYSTEMS

www.telco.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Virtualized Infrastructure Manager

Description: The CloudMetro 100 is a 10GE carrier-grade distributed NFV platform. By harnessing cutting-edge technologies, like Software Define Networking (SDN) and Distributed Networking Functions Virtualization (D-NFV) CloudMetro 100 enables service providers to turn their networks from transport networks into IT-aware networks.

Uniqueness: High-availability and resiliency; Traffic bypass of applications in case of CPU failure; Low footprint as a demarcation/CPE device; Centralized remote management and control by the carrier; Service activation, throughput testing, and troubleshooting. On-going monitoring with hardware-based load and accuracy required to meet current SLAs based on the OAM standards.

Supported Hypervisors	**Supported CMP**
KVM	OpenStack
Supported OS	**Customers**
Linux (Ubunto and Fedora)	Tier 1 carrier in Asia-Pacific, Tier 2 in Central Europe, Tier 1-3 in North America

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vCloud NFV Platform

(Click for online version)

www.vmware.com/files/pdf/solutions/vmware-nfv-solution-brief.pdf

VMWARE, INC.

www.vmware.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: Virtualized Infrastructure Manager, Day 2 Operations Management

Description: By delivering on a multi-VIM strategy and leveraging VMware's leading virtualization platform components, vCloud NFV delivers CSPs an NFV platform that is production proven, enables rapid time to market and supports multi-vendor VNFs at all levels of maturity.

Uniqueness: Operational capabilities of vCloud NFV are provided through vRealize Operations and vRealize Log Insight. Self-learning algorithms and predictive analytics correlate monitoring data and provide intelligent alerts on underlying performance issues and provide recommendations for corrective action. Capabilities include: Intelligent event correlation for fault diagnosis and root cause analysis that minimizes the time to identify and resolve causes of failure. Patented analytics engine and predictive analytics to identify developing faults take action before they impact service availability.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux, Windows	Available on request

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6WINDGate Packet Processing Software

(Click for online version)

www.6wind.com/wp-content/uploads/2014/10/6WINDGate-Solution-Brief-Letter-Size-Jun-15.pdf

6WIND

www.6wind.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: 6WindGate is a software networking stacks that can be used to remove Linux Bottlenecks in the creation of NFV products.

Description: The 6WINDGate software provides network performance enhancements for physical and virtualized architectures, through a comprehensive set of optimized Layer 2 through 7 networking protocols optimized for general-purpose platforms and fully compatible with standard hypervisors.

Uniqueness: To provide the maximum performance, 6WindGate implements a packet processing engine which is isolated from the Linux operating system called the fast path. The same source is supported by several processors such as Tilera, Intel, Broadcom, and Cavium.

Supported Hypervisors	Supported CMP
ESXi	OpenStack
Supported OS	**Customers**
Linux (Debian, Ubuntu, RedHat,)	Not Provided

6WIND Virtual Accelerator

(Click for online version)

www.6wind.com/wp-content/uploads/2016/03/Virtual-Accelerator-Data-Sheet.pdf

6WIND

www.6wind.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: SW Acceleration

Description: 6WIND Virtual Accelerator provides accelerated virtual switching and networking features for virtual infrastructures to enable Network Function Virtualization (NFV), data center virtualization and network appliance virtualization.

Uniqueness: 6WIND Virtual Accelerator runs inside the hypervisor domain and removes Linux performance bottlenecks by offloading virtual switching from the networking stack. The CPU resources necessary for packet processing are drastically reduced, so that less cores are required to process network traffic at higher rates and Linux stability is increased. It supports a complete set of networking protocols to provide a complete virtual networking infrastructure.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Red Hat Enterprise Linux, OSP6, OSP7, Ubuntu, CentOS)	NGI (Italian Service Provider), ALU/Nokia

FSP 150 ProVM

(Click for online version)

www.advaoptical.com/en/products/carrier-ethernet/fsp-150-provm.aspx

ADVA OPTICAL NETWORKING

www.advaoptical.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: EMS, HW acceleration, SW acceleration, NFV hardware platform

Description: FSP 150 ProVM is an edge NFV product series that consolidates several customer premise appliances into one box. This box is at once a server capable of hosting applications and a demarcation device that can monitor applications, secure network traffic, and deliver highly precise synchronization. FSP 150 ProVM is built on open protocols and utilizes open source software for virtual infrastructure management.

Uniqueness: Embedded physical hardware data plane for low latency path, Hardware based SAT and in service monitoring of service and server / VNF performance. Accurate time distribution. Tightly integrated management of physical and virtual functions.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	
Linux (Gentoo Linux 3.14.25)	

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Fast Path Accelerator

(Click for online version)

www.aricent.com/software/communications-infrastructure/sdn-nfv-cloud

ARICENT

www.aricent.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: SW acceleration, SDK to build NFV solutions

Description: Aricent's Fast Path Accelerator (FPA) is data-plane processing software for multi-core platforms. FPA implements the OpenFlow Packet Forwarding Pipelines.

Uniqueness: High performance scalability, ability to integrate with third-party vendor control planes, portable across processors

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack
Supported OS	**Customers**
Linux (Various)	Cisco, Nokia, Vodafone, Yahoo, HPE

Cavium ThunderX ARMv8 Processors

(Click for online version)

www.cavium.com/pdfFiles/ThunderX_PB_Rev2.pdf?x=2

CAVIUM NETWORKS

www.cavium.com/company.html

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Hardware Platform

Description: The ThunderX product family provides the best in class 64-bit ARMv8 data center & cloud processors, offering unprecedented level of integration and industry leading SoC performance.

Uniqueness: This is the first ARM-based SoC scaling up to 48 cores, 2.5 GHz core frequency. It's also the first ARM-based SoC supporting fully cache coherent across dual sockets using Cavium Coherent Processor Interconnect (CCPI). It has plenty of integrated hardware accelerators for security, storage, networking, and virtualization applications. It is a standards-based low latency Ethernet fabric interconnecting thousands of ThunderX nodes in various configurations and enabling fabric monitoring and SLA enforcement with awareness and policy enforcement for virtualized networks.

Supported Hypervisors	Supported CMP
KVM, Xen	Not provided
Supported OS	**Customers**
Linux (Various Linux distributions), FreeBSD	Alcatel-Lucent, Aruba Networks, Cisco, Citrix, F5 Networks

Corsa 10G/100G SDN Switches

(Click for online version)

www.corsa.com/products

CORSA TECHNOLOGY

www.corsa.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: NFV Hardware Platform

Description: The Corsa DP6430 (2x100G + 24x10G) and DP6440(4x100G + 24x10G) are OpenFlow data plane switches. They offer full flexibility, scale and performance for at-scale SDN networks.

Uniqueness: The Corsa data planes are exceedingly quick and easy to install and configure for use. They are fully compatible with any controller speaking OpenFlow 1.3+ on their southbound interface and has operated directly with Ryu,NOX/POX 1.0, OpenDaylight, Vandervecken and others.

Supported Hypervisors	Supported CMP
Not provided	Not provided
Supported OS	**Customers**
ONOS	Not provided

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Dell Open Networking Switches

(Click for online version)

www.dell.com/us/business/p/open-networking-switches/pdf

DELL

www.dell.com

OPNFV: Y **ETSI NFV ISG:** N

Sub-Category: NFV Hardware Platform

Description: Dell Open Networking Switches are 1/10GbE and 10/40GbE top-of-rack (ToR) switches that are purpose-built to accelerate applications and improve workload management.

Uniqueness: The Dell Solution lets you build a solution on industry-standard Intel x86 compute platforms combined with open networking platforms and a rich set of open interfaces – ensuring maximum interoperability, manageability and investment protection.

Supported Hypervisors	Supported CMP
ESXi	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux (Cumulus Linux), Big Cloud Fabric, IP Infusion, Midokura Enterprise MidoNet, Pluribus Networks Nevisor OS	www.dell.com/learn/us/en/uscorp1/customer-stories?c=us&l=en&s=corp&cs=uscorp1

EMC Provider Cloud System (PCS)

(Click for online version)

www.emc.com/emctelco/EMC-PCS-1.0-Solution-Brief.pdf

EMC

www.emc.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Hardware Platform, NFV Software Platform

Description: The EMC Provider Cloud System (PCS) is a software-defined Network Functions Virtualization Infrastructure (NFVI) reference architecture designed to enable communications service providers' (CSPs') to deliver distributed, multi-service, carrier-grade cloud solutions quickly and economically.

Uniqueness: The EMC PCS is a "software defined reference architecture," for VARs to provide components to service providers. It is built on Commodity Off the Shelf (COTS) hardware and offers communications service providers the choice between turnkey, engineered systems and building blocks for larger-scale deployments. It is integrated with open standards and Application Programming Interface (API) instrumentation at all layers allowing providers to choose between Open Source and proprietary software.

Supported Hypervisors	Supported CMP
ESXi	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux	Not Provided

Ericsson Cloud Execution Environment

(Click for online version)

www.ericsson.com/ourportfolio/products/cloud-execution-environment?nav=productcategory008%7Cfgb_101_0537

ERICSSON

www.ericsson.com

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: HW acceleration, SW acceleration, NFV hardware platform, NFV software platform

Description: Ericsson Cloud Execution Environment is the virtualization, control and management layer in Ericsson Cloud System. It is an OpenStack based cloud platform securing that both telecom virtual network functions and IT applications can share the infrastructure resources in terms of compute, storage and network.

Uniqueness: Differentiation in three main areas; High performance, reliability, and operation and maintenance. For high performance we focus on high throughput, quality of service, and hypervisor enhancements. For reliability we have eliminated all single points of failure of OpenStack.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack
Supported OS	**Customers**
Linux (Ubuntu, SUSE, WindRiver, etc.), Windows (Windows Server, all current editions)	XL Axiata, Telstra, Swisscom, Softbank, Telefónica, Digicel

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NPS-400 Network Processor

(Click for online version)

www.mellanox.com/related-docs/prod_npu/PB_NPS-400.pdf

EZCHIP

www.ezchip.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: HW acceleration

Description: NPS-400 flexibility enables building platforms that deliver a wide variety of applications for layer 2-3 switching and routing, layer 4-7 stateful session processing, and packet payload manipulation. Integration allows system vendors to deliver solutions that are cost effective as well as power and board-space efficient.

Uniqueness: The NPS uniquely features a combination of unmatched Technology(10 times smaller and faster C-programmable Task Optimized Processors), Performance (400 gigabit wire-speed packet processing), Flexibility (advanced services and full layers 2-7 stateful processing), Simplicity, Versatility, Applications

Supported Hypervisors	Supported CMP
Not Provided	OpenStack
Supported OS	**Customers**
Linux (Standard distribution)	ZTE

HPE NFV System Family

(Click for online version)

www8.hp.com/us/en/products/solutions/product-detail.html?oid=8326286#!tab=features

HEWLETT PACKARD ENTERPRISE (HPE)

www.hpe.com/us/en/home.html

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Software Platform

Description: The HPE NFV System family of solutions provides a complete foundation for communications service providers (CSPs) to host network functions in a network functions virtualization (NFV) environment.

Uniqueness: NFV System is completely factory integrated and engineered specifically for NFV workloads. HPE has distilled the learnings of many PoCs and lab efforts with partners and carriers and created NFV System to enable carriers to rapidly move to deployed solutions. Many built in features such as automated installers, automated compute node expansion, single pane log audits and more allow this product to be easily operationalized.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Helion OpenStack Carrier Grade	Not Provided

Intel Open Network Platform Server

(Click for online version)

www.intel.com/content/www/us/en/communications/open-network-platform-server-datasheet.html

INTEL

www.intel.com/content/www/us/en/homepage.html

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Hardware Platform, NFV Software Platform, SDK to build NFV solutions

Description: Intel Open Network Platform Server Reference Design (Intel ONP Server Reference Design) is a platform-level reference architecture designed to make it easier for integrators and service providers to develop and deploy software-defined networking (SDN) and network function virtualization (NFV) solutions.

Uniqueness: The Intel Open Network Platform (Intel ONP) release 2.0 introduces new functionality, enhanced performance, and greater stability. Price-sensitive deployments, such as vE-CPE, will benefit from integration with the Intel Xeon processor D-1500 product family and the Intel Atom processor C2000 product family of SoC. Support for the Community Enterprise Operating System (CentOS) is now available with improved network interoperability through integration with the latest open source ingredients.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	
Linux (Fedora 22 Real-Time Linux Kernel, version: 3.18.24-rt22)	

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Mellanox MSX1410-OCP (Click for online version)

www.mellanox.com/related-docs/prod_silicon/PB_ConnectX-4_Lx-EN_IC.pdf

MELLANOX TECHNOLOGIES

www.mellanox.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: HW Acceleration, SW Acceleration, NFV Hardware Platform

Description: The MSX1410-OCP switch is a top of rack switch with 48 ports of 10BgE and 12 uplink ports of 40GbE for non-blocking throughput between rack and aggregation layer. Based on advanced hardware design, this switch packs 48 SFP+ and 12 QSFP interfaces in an ultra-dense 1U form factor.

Uniqueness: Open Composable Networks at Extreme speed of 10/25/40/50/100GbE end to end. Mellanox ConnectX-4 series of NICs: – Best DPDK performance of 75 million pps for 100G interface and 33 million pps for 25G interface – SDN control plane with accelerated data plane through NIC ASIC: Embedded switch in NIC capable of vSwitch offload.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	
Linux, Windows, VMware(R) ESX/ESXi 6.0	

Midokura Enterprise MidoNet

(Click for online version)

https://s3.amazonaws.com/midokura-marketing-materials/Datasheets/MidoNet-Datasheet-2014.pdf

MIDOKURA

www.midokura.com

OPNFV: Y **ETSI NFV ISG:** N

Sub-Category: NFV Software Platform

Description: Midokura Enterprise MidoNet is a commerical product combining the most stable, production hardened version of MidoNet for Network Virtualization with the MidoNet Manager, longer-term support, and enterprise-class 24×7 service level agreement.

Uniqueness: MidoNet is the first truly open source, hardware-agnostic network virtualization overlay solution. With MidoNet, cloud operators have flexibility and full control of their virtual networks like adding capacity and/or making changes on the fly, all without disturbing the physical layer. Customers can run MidoNet on their choice of brite box or OEM networking equipment.

Supported Hypervisors	Supported CMP
ESXi, KVM, Docker	OpenStack, vSphere, HP Helion Eucalyptus, Custom Platforms
Supported OS	**Customers**
Linux (RHEL 7, Ubuntu 14.04),	www.midokura.com/customers

Netronome Agilio CX 10GbE and 40GbE Intelligent Server Adapter

(Click for online version)

www.netronome.com/media/redactor_files/PB_Agilio-CX_1x40GbE.pdf

NETRONOME

www.netronome.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: HW Acceleration, SW Acceleration, NFV Hardware Platform

Description: The Agilo CX 10GbE and 40GbE Intelligence Server Adapter is a standard low-profile PCIe intelligent server adapter that is designed for general-purpose x86 commercial off-the-shelf (COTS) rack servers, fitting needed power and form factor requirements.

Uniqueness: Agilio-ISA is the only intelligent NIC available in the industry, which provides the use of OVS features with the SR-IOV for VM interface. Agilio software replicates the kernel software based OVS data path in the Agilio-ISA hardware; therefore flow matching and corresponding actions are performed in the hardware instead of software.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Ubuntu, CentOS, RHEL)	Cisco, Juniper, SS8 Networks, NTT Communications

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NoviFlow NoviSwitch 2128

(Click for online version)

http://noviflow.com/products/noviswitch

NOVIFLOW INC.

http://noviflow.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: NFV Hardware Platform, NFV Software Platform

Description: NoviFlow delivers commercial-grade switches that implement all OpenFlow 1.3 actions, instruction, and matching fields. They also deliver key features of OpenFlow 1.4, offering up to 240 gigabits per second of genuine wire-speed performance, 1 million flow entries and over 14,000 flow mods/sec.

Uniqueness: The NoviFlow switch family was specifically designed for deployment in data centers looking to leverage the benefits of software-defined networking to improve the cost/performance, security, scalability and flexibility of networks. They deliver maximum OpenFlow capability in a compact form factor.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Proprietary Linux-based NoviWare host CPU software)	http://noviflow.com/about/our-clients-and-partners

NoviWare

(Click for online version)

http://noviflow.com/wp-content/uploads/NoviWare-300-Datasheet-V2_1.pdf

NOVIFLOW INC.

http://noviflow.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: NFV Software Platform

Description: NoviFlow is raising the speed benchmark for SDN to 240 gigabits per second (Gbps) by integrating network processors with the NoviWare intelligent switching software. NoviFlow offers NoviWare for EZchip NP-4 and NP-5 network processors, and can customize the solution as needed to meet other hardware requirements.

Uniqueness: NoviWare is the first high-performance OpenFlow 1.3 and 1.4 compliant switch software available for license to network equipment manufacturers. It allows OEM's to significantly accelerate their time-to-market of full-featured OpenFlow 1.3 and 1.4 offerings.

Supported Hypervisors	Supported CMP
KVM	OpenStack
Supported OS	**Customers**
Linux (Proprietary Linux-based NoviWare host CPU software)	http://noviflow.com/about/our-clients-and-partners

Nuage Networks Virtualized Services Platform (VSP)

(Click for online version)

www.nuagenetworks.net/wp-content/uploads/2014/11/MKT2014097652EN_NN_VSP_Virtualized_Services_Platform_R3_Datasheet.pdf

NUAGE NETWORKS

www.nuagenetworks.net

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: NFV software platform. The VSP consists of software-based policy management and analytics, SDN controller, virtualized routing, and switching.

Description: The Nuage Networks Virtualized Services Platform (VSP) lays the foundation for an open and dynamically controlled datacenter network fabric to accelerate application programmability, facilitate unconstrained mobility, and maximize compute efficiency.

Uniqueness: The Nuage VSP provides support for all major cloud management systems, hypervisors, and network gear. It leverages VMs on any x86-based hardware. It offers unrestricted placement of VM workloads to maximize efficiency of server resources.

Supported Hypervisors	Supported CMP
ESXi, KVM, Xen, Linux Containers	OpenStack, VMware vRealize/vCAC/vCD, CloudStack
Supported OS	**Customers**
Linux (Compatible and tested with distributions from Red Hat, Ubuntu, and CentOS)	My Republic, Orange, China Mobile, China Telecom, OVH

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Red Hat NFV Platform

(Click for online version)

www.redhat.com/en/technologies/industries/telecommunications/nfv-platform

RED HAT

www.redhat.com/en

OPNFV: Y **ETSI NFV ISG:** Y

Sub-Category: NFV Software Platform

Description: The Red Hat network functions virtualization (NFV) platform is built on Red Hat Enterprise Linux OpenStack Platform. It is combined with key partners to power the complete NFV solution.

Uniqueness: Red Hat is playing a leading role in working with industry leaders to deliver carrier-grade OpenStack.

Red Hat has a proven record in developing commercial ecosystems around an open infrastructure platform, fostering a strong network of technology providers to deliver enterprise features needed for mission-critical deployments.

Supported Hypervisors	Supported CMP
ESXi, KVM, Hyper-V	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux (Red Hat Enterprise Linux)	TMG, Chunghwa Telecom, Bayer Business Services, Gulf Air, Novamedia

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category: ■ Monitoring and Testing

SkyLIGHT

(Click for online version)

https://accedian.com/wp-content/uploads/2015/05/Accedian-VCX-Controller-Product-Brief-2016-1Q.pdf

ACCEDIAN NETWORKS INC.

https://accedian.com

OPNFV: N **ETSI NFV ISG:** N

Description: SkyLIGHT, Accedian's Solutions Architecture, provides operators with the performance visibility required to take the self-optimization promise of SDN and SON and execute it on multivendor, heterogeneous, mobile backhaul networks (MBH-SON) using standards-based technology.

Uniqueness: The SkyLIGHT VCX Controller is a performance assurance controller employing NFV to bring monitoring capabilities network-wide. This gives carriers all the benefits of virtualization by eliminating key cost, scalability, and coverage barriers to network performance visibility.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD
Supported OS	**Customers**
Linux (RedHat, Ubuntu)	Not provided

H-Log ADVISOR SLA

(Click for online version)

www.hlog-qostelecom.com/uploads/media/files/advisor-sla-brochure.pdf

H-LOG QOS TELECOM

www.hlog-qostelecom.com

OPNFV: N **ETSI NFV ISG:** N

Sub-Category: Advisor SLA is an NFV orchestration solution for end-to-end Quality of Service (QoS) monitoring

Description: Advisor SLA is a proactive solution to monitor the network efficiency (performance) by checking the QoS between several strategic points on the virtual or physical network infrastructure (24x7) and to check the compliance of the service level agreement contracts.

Uniqueness: Advisor SLA provides a complete visiblity of the performance of any IP-based network infrastructure with real time measurement, scalable hardware and software active probes, and open architecture capabilities, to minimize operational costs. It can integrate into existing OSS by using a standard web services RESTful API.

Supported Hypervisors	Supported CMP
Not provided	Not provided
Supported OS	**Customers**
Linux, The interface is a web-based GUI	Orange, Telecom Italia, MGTS, Telmex, Renater, and FCCN

Ixia IxNetwork

(Click for online version)

www.ixiacom.com/sites/default/files/resources/datasheet/ixnetwork_overview_1.pdf

IXIA

www.ixiacom.com

OPNFV: Y **ETSI NFV ISG:** Y

Description: The IxNetwork test application supports OpenFlow protocol emulation fully integrated with other network protocols. Providing the first set of OpenFlow compliance tests, Ixia successfully simulates and validates SDN via OpenFlow to ensure that network infrastructures can handle market needs within a secure, efficient networking environment.

Uniqueness: IxNetwork offers a solution for functional and performance testing by using emulation for routing, switching, multi-protocol label switching (MPLS), IP multicast, broadband access, authentication, carrier Ethernet, data center bridging (DCB), and software defined networking (SDN) protocols. Scales to handle large networks and provides wire-rate traffic generation with service modeling.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack
Supported OS	**Customers**
Linux (RedHat, Ubuntu 14.04 LTS, CentOS 7.0)	Not Provided

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category: ■ Monitoring and Testing

SuperCloud

(Click for online version)

http://supercloud.luxoft.com/resources/brochure

LUXOFT

www.luxoft.com

OPNFV: N **ETSI NFV ISG:** Y

Sub-Category: Orchestration

Description: Luxoft's SuperCloud NFV orchestration platform is built to enable today's telecom operators and large enterprises to transform their traditional network services infrastructure into NFV.

Uniqueness: The key value proposition of SuperCloud is that it is designed from DevOps and service automation mindset to fulfill the needs of network administrators that support IT application developers practicing agile software development. It is vendor neutral and completely hardware independent.

Supported Hypervisors	Supported CMP
KVM, XenServer	OpenStack
Supported OS	**Customers**
Linux	Not provided

Saisei FlowCommand

(Click for online version)

http://saisei.com/wp-content/uploads/Saisei-Datasheet-Product-Overview.pdf

SAISEI

http://saisei.com

OPNFV: N **ETSI NFV ISG:** Y

Description: Saisei FlowCommand is a flow-policy control, analytics and security solution that aims to double the usable bandwidth in deployed networks. The Saisei FlowCommand family of Network Performance Enforcement products including FlowCommand, FlowEnforcer, and FlowVision subsume or replace some of the functionality of older, stand-alone appliances, such as WAN optimizers, packet shapers, application delivery controllers, APMs, NPMs, IDSs, next-gen firewalls and more.

Uniqueness: Based on patented flow-engine technology that literally changes the way that chaotic, routed TCP/IP networks behave, Saisei's FlowVision, FlowEnforcer, and FlowCommand products are capable of concurrently monitoring 5 million concurrent flows on a 10Gb link 20 times per second, and evaluating and/or taking action on those flows across policies based on more than 30 metrics.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack
Supported OS	**Customers**
Linux (Ubuntu 14.04, Centos 6.5/KVM, VMware/ESXI5.5), VMware ESXi	First Cagayan Converge Data Center, Inc. (FCCDCI), Gogo Inflight, NHN Entertainment Corporation

Spirent Hyperscale Test Solution

(Click for online version)

www.spirent.com/~/media/Datasheets/Broadband/PAB/SpirentTestCenter/Spirent_HyperScale_Test_Solution_datasheet.pdf

SPIRENT

www.spirent.com

OPNFV: Y **ETSI NFV ISG:** Y

Description: Spirent HyperScale test solution meets extreme scale testing needs. Its modular approach can simulate thousands of real-world environments to test and validate your entire data center infrastructure.

Uniqueness: Service providers need to validate their infrastructures to handle thousands of VMs and meet the traffic requirements of a modern cloud datacenter. Testing at such extreme scales cannot be done with typical test tools. Spirent HyperScale test solution is the industry's first solution to meet extreme scale testing needs. Its modular approach can simulate thousands of real-world environments to test and validate an entire data center infrastructure.

Supported Hypervisors	Supported CMP
ESXi, KVM, Ubuntu 14.04, Oracle VM, and Baremetal	OpenStack, VMware vRealize/vCAC/vCD, CloudStack
Supported OS	**Customers**
Software is available in OVA, qcow2, rpm and deb formats	Not Provided

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Veryx SAMTEST – NFV

(Click for online version)

www.veryxtech.com/wp-content/uploads/2015/10/Datasheet-SAMTEST-NFV.pdf

VERYX TECHNOLOGIES INC.

www.veryxtech.com

OPNFV: N **ETSI NFV ISG:** N

Description: Veryx SAMTEST for NFV service assurance is a solution addressing various aspects of NFV performance management – from NFV architecture benchmarking in lab, pre-deployment verification in the field, NFV based service activation, monitoring, on-demand measurements and troubleshooting.

Uniqueness: SAMTEST is a one-stop solution covering various aspects of NFV-based service life cycle performance management encompassing: benchmarking NFV architectures against traditional networks, service turn-up testing and troubleshooting, monitoring of services and network functions and on-demand diagnostics of live deployments. It provides flexibility of using physical and virtual probes.

Supported Hypervisors	Supported CMP
ESXi, KVM	OpenStack, VMware vRealize/vCAC/vCD, CloudStack
Supported OS	**Customers**
Linux (Fedora Core 13,17, 20 | CentOS 5.5, 6.5, 6.6(64 bit) | Ubuntu 12.04.4 (64 bit))	www.veryxtech.com/resources/case-study

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The Trusted News and Resource Site for SDx, SDN, NFV, Cloud and Virtualization Infrastructure

Rev B