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NFV adoption to transform telecommunications infrastructure

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This report underwritten by: Wind River

a cloud report

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02/25/2014

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Communications Service Providers (CSPs), including wire line, wireless, and cable providers, need to innovate to keep up with the competitive pressure of the rapidly changing network environment. As more of the value (and revenues) flow to over-the-top service providers like Google and Amazon, CSPs face the prospect of increasingly becoming providers of commodity-like transport services. At the same time, the huge growth in traffic driven by video, mobile, and cloud usage is overwhelming current networks, forcing CSPs to spend heavily in new equipment just to keep up with bandwidth demand.

The answer for most leading CSPs is to improve their ability to introduce new revenue-generating services, increase customer satisfaction, and reduce their costs. A key part of this telecom transformation is for the CSPs to modify their traditional network architectures significantly to improve agility and reduce operating costs. CSPs need networks that can rapidly respond to changing traffic patterns, new applications, and user requirements.

The IT market offers many lessons for the telecom industry transformation, including rapid innovation, reliance on standardized servers and operating systems, and a robust independent software (ISV) ecosystem. CSPs want to extend these benefits of IT to the carrier network to help transform the network:

- CSPs must modernize and transform their networks so that they can rapidly enable new revenue producing services and to profitability handle large growth in wire line and wireless traffic
- NFV is a key technology that enables CSPs to transform their networks so that they can deliver new services and reduce costs quickly. Service agility is key.
- The migration to NFV requires telecom specific virtualization software to deliver real time traffic, scale to hundreds of millions of users, and support high reliability (99.999% uptime).

Network Functions Virtualization (NFV) includes many technologies that will enable CSPs to create more agile networks.

Thumbnail image courtesy of Randy Faris/Fuse/Thinkstock.

Introducing NFV

Network functions virtualization (NFV) is an initiative driven by several dozen large CSPs that dramatically increases the use of virtualization and commercial off-the-shelf (COTS) systems in their networks. Telecom infrastructure has long been a bastion of proprietary software running on purpose-built hardware. NFV leverages IT technologies – including virtualization, standard servers, and open software – so that it can fundamentally change the way networks are built and operated. The goal is to consolidate multiple network functions on these COTS platforms and enable each function (application) to scale capacity elastically.

In the fall of 2012, a number of the largest CSPs initiated an effort (in ETSI) to dramatically increase the use of virtualization and COTS technology in their telecommunications networks. A year later, a larger group of 50+ CSPs and industry suppliers introduced a number of specifications to guide NFV adoption.

The key benefits that CSPs will derive from NFV implementation include:

- Faster time to market
- Enabling new services quickly
- Rapidly scaling resources up and down
- Lowering costs (both capex and opex)

The challenge is to adopt IT technologies to the telecom industry requirements of high reliability, low latency, and the ability to scale to support hundreds of millions of users.

SDN in the telecom network

SDN provides separation of the control and data plane where the intelligence of the switch or router is split from the packet forwarding engine. This separation provides opportunities to program the network and for development of new architectures to deliver network functionality. NFV functions, such as load balancing, security, and DPI require cooperation with the data plane and can benefit significantly from a SDN programmable data plane. Service chaining is an excellent example of how NFV and SDN can function together; efficiently and optimally stringing together a series of services (packet inspection, encryption, etc.) for specific packet flow requirements.

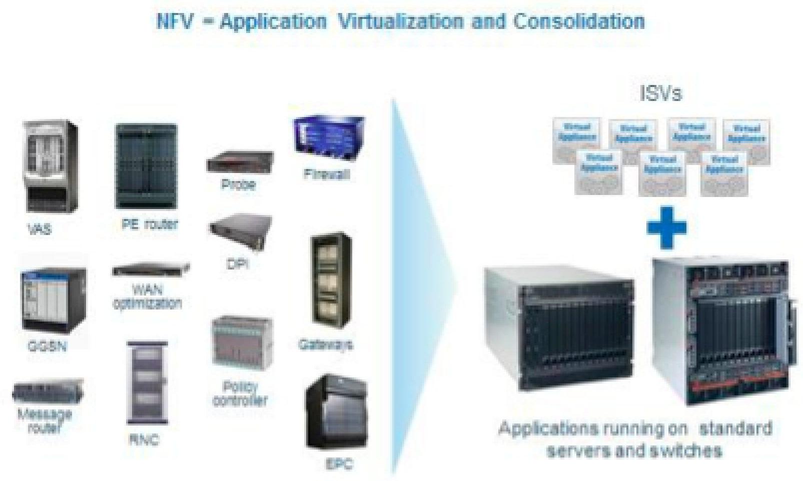
Role of IT hardware and software in the telecom network

COTS is shorthand for industry-standard servers and storage, merchant semiconductors (e.g., Broadcom and Cavium), and standard operating systems (e.g., Linux). Advances in IT technology, including more powerful processors (e.g., Intel x86), faster switching fabrics (e.g., 40GB), and advances in network software (e.g., SDN and NFV) have brought a wealth of network functions in scope for COTS.

COTS (and NFV) proponents hope to virtualize a wide range of network elements, including:

- Mobile core networks
- Deep packet inspection (DPI)
- Session boarder controllers (SBC)
- Security appliances including encryption, intrusion detection, and firewalls
- Server load balancers
- WAN acceleration
- Video servers

NFV = application virtualization and consolidation



(Source: ETSI)

COTS is already in widespread use in telecom networks, specifically in application servers, wire line and wireless core, OSS/BSS, and CSP data centers. Network equipment providers (NEPs) and CSPs deploying COTS report significant benefits in new system design, including one-third less development time and one-third less system costs – according to research by Doyle Research. The leading providers of COTS hardware include HP, IBM, Dell, and Radisys. The leading providers of COTS software include Wind River, MontaVista, and 6Wind.

Challenges of telecom virtualization

The challenge (and opportunity) for NFV is to leverage the advantages of the IT ecosystem while minimizing the potential disadvantages. IT servers and software must be modified to meet the specific reliability requirements in the telecom environment, including 99.999 percent uptime. This 5 9s reliability is a key requirement and a differentiating factor between traditional IT (just reboot the system) and telecom (where downtime or poor performance is not acceptable).

To meet design goals without sacrificing performance, software applications must be specifically designed or rewritten to run optimally in virtualized telecom environments to meet carrier grade requirements. Otherwise, applications ported to virtualized environments may pay a significant performance “tax” and not be able to scale to required network load. An additional challenge for virtualization in the telecom environment is to be able to offer very low latency to handle real-time applications such as voice and video traffic.

Benefits of NFV

CSPs planning to implement NFV expect a wide range of benefits, including:

- The ability to deliver new services to market faster
- Improved customer satisfaction and retention
- Lower operational costs
- Lower costs to deploy new network equipment.

A key element of NFV is the ability of the telecom market to leverage the rapid innovation cycle of the IT market by enlisting an ecosystem of independent software vendors (ISVs) and the open source community to develop new revenue producing applications. In addition, CSPs can save significant time in deploying new services such as virtual applications on standard servers (VMs). These new services can be deployed flexibly in response to customer demand by geography and scaled elastically to increase performance (by adding VMs) as required.

NFV can help CSPs realize significant cost savings on both opex and capex. For capex, CSPs can take advantage of the economies of scale in the IT industry by leveraging applications running on COTS – instead of specialized, single-function network equipment. CSPs can also consolidate their network equipment by combining multiple network functions onto a single server, thereby reducing hardware cost, floor space, and cabling requirements. In addition, virtualization software provides support for multi-tenancy, thus giving CSPs the ability to support multiple users on the same hardware platform, reducing the amount of equipment network operators need to purchase.

On the opex side, CSPs can (over time) significantly reduce the enormous costs to build, operate, and manage their networks. Virtualized applications running on COTS platforms are easier to build, provision, and operate as compared to the dozens of proprietary hardware boxes currently in their network. NFV also reduces energy consumption via server power management and dynamic workload rebalancing, which lowers power consumption during off-peak periods.

Network operators (both fixed and mobile) need to optimize the network to handle the explosive growth in data (e.g., video) traffic. For example, virtualized deep packet inspection (DPI) can provides the detailed information on traffic flows to allow operators to offload traffic (e.g., to Wi-Fi), prioritize traffic, to provision new services, and new pricing models. Providing customers high levels of user experience (quality) will be a critical differentiator for many operators.

CSPs surveyed by Doyle Research expect a wide range of benefits from their NFV deployments, including:

- Better cloud/network efficiency
- Ability to balance traffic demands
- Improved network management
- Ability to introduce new services faster

NFV use cases

One of the leading goals of the ETSI NFV group is to examine and test a number of use cases for NFV deployment in real network operations.

The CSPs describe a wide range of use cases for NFV including:

Network monitoring

Security as a Service

CDN

Cloud RAN

Evolved Packet Core (EPC) in the mobile network

WAN traffic balancing/shaping

Virtual IMS and RCS

Virtual BRAS

Virtual CPE – business and consumer

Given the early stages of NFV testing and adoption it is difficult to predict which use cases will be the first one to see implementation. However, NFV applications that can be incrementally implemented to offer new services (e.g. network security) or be deployed in Greenfield environments are likely to see early adoption.

Different stages of NFV

CSP adoption of NFV is likely to occur in a phased approach, especially when modifying existing network architectures. There are four (potential) phases that CSPs may adopt – depending on application and use case.

Migration to COTS

COTS hardware has long been a critical component of telecommunications networks. This phase involves the migration from purpose-built hardware to software running on general purpose servers. NFV will expand COTS use in the network from applications in the core network, out to edge and even access devices as network equipment providers begin to offer software-based versions of their equipment running on standard IT servers

Virtualization of software functions

In this phase, the software applications are optimized to run in virtualized data center environments. Telecom equipment must be highly reliable (99.999 uptime), high performance, and scale to support hundreds of millions of users. This step requires more than just virtualizing a software application. Performance considerations for packet throughput, hardware latencies must be taken into consideration and may require a re-architecture of the application.

Elasticity capacity

One of the key (potential) benefits of NFV is the ability to easily scale up and scale down applications based on network load, time of day, and special events (e.g., the World Cup). Running NFV applications in a virtualized data center can offer the elastic (cloud-like) capacity needed by large SPs – given the ability of the application to scale and the appropriate ties to its specific OSS/BSS systems. Cloud technologies such as OpenStack can be used to create a virtual data-center architecture that enables the management of virtual applications to scale over an entire data center or network.

Orchestration of multiple virtual functions

By far the most difficult step will be to combine (service chain) a broad range of NFV applications across the network stack. For example, orchestration of routing, DPI, CDN, and security in a broadband network or implementation of a complete evolved packet core in a mobile network. Lack of NFV standards will make this orchestration especially complex in multivendor supplier scenarios. In addition, this orchestration engine will need to tie to specific SDN and OSS/BSS implementations.

Current status of NFV

All Tier 1 CSPs have a high interest in the implementation of NFV. Most of these CSPs have NFV in their labs as proof of concepts and many have or soon will deploy NFV in production deployments during 2014. As NFV technologies mature and pass in-house proof of concepts, leading CSPs will start to deploy NFV more widely during 2015 and 2016. We expect NFV to be broadly deployed across a wide range of applications and use cases by 2017.

Role of the NEPs

The major network equipment providers (NEPs) will need to change the way they build and architect telecommunications infrastructure. This means that Ericsson, Huawei, NSN, Cisco, Alcatel-Lucent, Juniper (and many other NEPs) who are used to selling networking products primarily as integrated HW/SW (aka boxes) will have to evolve towards a more software oriented product and sales model. This is a significant challenge for many of the larger NEPs and they will need to partner with IT suppliers and ISVs to migrate their systems to COTS and virtualize their software applications.

Role of the IT suppliers

IT suppliers will play a critical role in the transformation of the telecom network and the adoption of NFV. The goal is to leverage the innovation and cost curve of IT technologies and adapt them to NFV. The challenge is that many of the leading IT suppliers do not have the expertise to meet the reliability, quality of service, and real-time management challenges of the telecom market. IT suppliers will have to partner with suppliers with the expertise to adapt IT technologies to telecom requirements and to integrate them with existing networks, including complex OSS/BSS systems

Impact of the ISV community

A key requirement for the success of NFV is the emergence of an ISV community to drive innovation in virtualized telecom software. A vibrant telecom ISV community is a key element in unlocking the value proposition of NFV to speed innovation and reduce network operating costs.

The telecom industry has only a few application software suppliers outside the traditional NEPs with the exception of operational support and billing suppliers (OSS/BSS). The solution to the NFV software “gap” is the emergence of independent suppliers willing to take risks and move fast to develop a wide range of NFV software including:

DPI

Service assurance

Routing, firewalls

WAN optimization

RAN

SLA monitoring

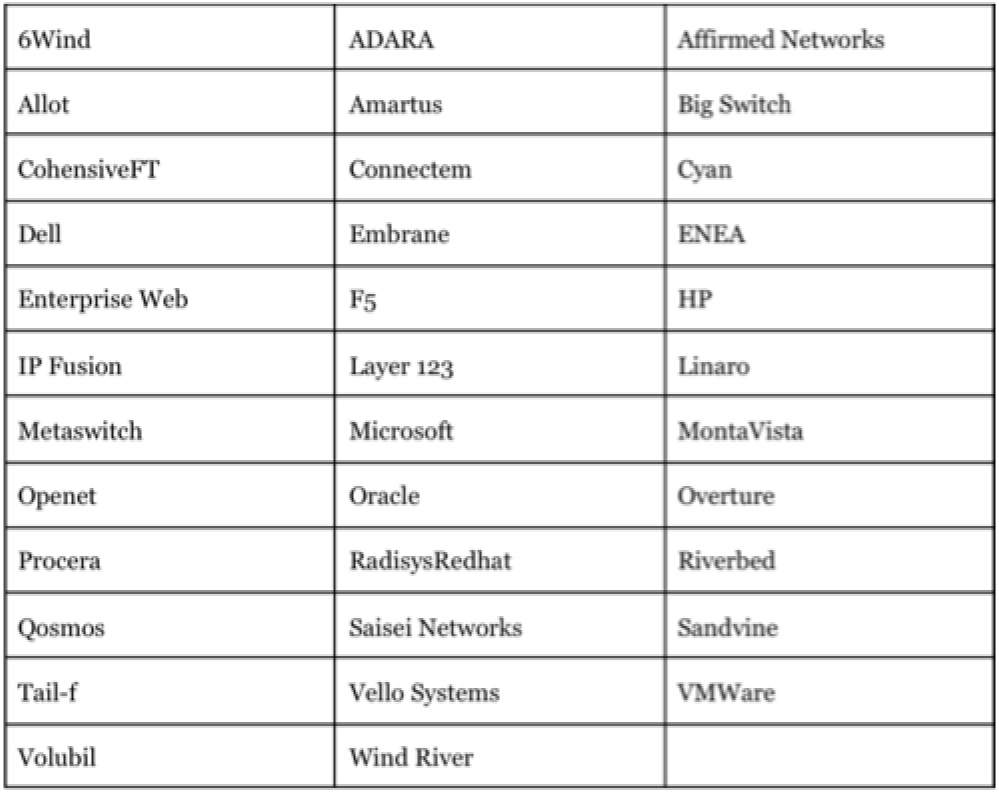
Security

CDN

Mobile core

Virtual CPE

This NFV software can come from wide range of potential NFV ISVs including:



6Wind	ADARA	Affirmed Networks
Allot	Amartus	Big Switch
CohensiveFT	Connectem	Cyan
Dell	Embrane	ENEA
Enterprise Web	F5	HP
IP Fusion	Layer 123	Linaro
Metaswitch	Microsoft	MontaVista
Openet	Oracle	Overture
Procera	RadisysRedhat	Riverbed
Qosmos	Saisei Networks	Sandvine
Tail-f	Vello Systems	VMWare
Volubil	Wind River	

The telecom network has always had very specific requirements for the reliability, performance, and latency of its systems. Increased adoption of IT technology (COTS) will not change these telecom specific requirements. NFV will still require operating systems/middleware with the following characteristics:

- High reliability – supporting 99.999 uptime
- Rapid packet handling
- Consistency in latency and throughput
- Strong security features

The primary change with NFV is moving the existing and new applications into a virtualized environment. So a high performance, highly reliable and secure hypervisor is the foundation and first step for NFV. But these characteristics must be applied to all aspects of an NFV host or server. For example, a critical aspect of performance is the communications between applications or services in an NFV host. A high performance virtual switch is critical to manage the flow of communications to the virtualized network functions (VNFs) running on various VMs. Introduction of a hypervisor into the new architecture should not create any data plane performance degradation when migrating the legacy applications to a new NFV architecture.

Another key aspect is management transparency. A new model for managing all the virtual services is usually required and this will have to be integrated into existing network management systems and OSS/BSS. This need to integrate new management models into existing systems is often seen as the largest hurdle to a complete NFV migration.

There are multiple aspects of an NFV host or server that need to be considered when building or migrating to a new architecture:

- The host operating system platform (usually some form of open source Linux) that must include an open ecosystem (standards-based) with open APIs and support for a broad variety of hypervisors and guest operating systems
- The hypervisor itself which must support applications and services residing in virtual machines that require real-time access to the hardware and fast-path packet delivery. This is especially important for real time application such as video, charging, and other latency sensitive applications
- Separation of VMs in secured containers for strong security
- A fast-path data plane for packet delivery, routing, VM communication and other data flows. The data plane must have similar levels of performance supporting virtualized applications as the applications would in a single-purpose appliance
- Management and orchestration of virtual machines and other virtual resources including the network subnets and storage. This includes the live VM migration to support elastic scaling of NFV applications
- Management interfaces to existing Network Management systems and OSS/BSS

The NFV software stack providers

Implementation of NFV in network elements requires a range of critical elements, including (see Figure 2):

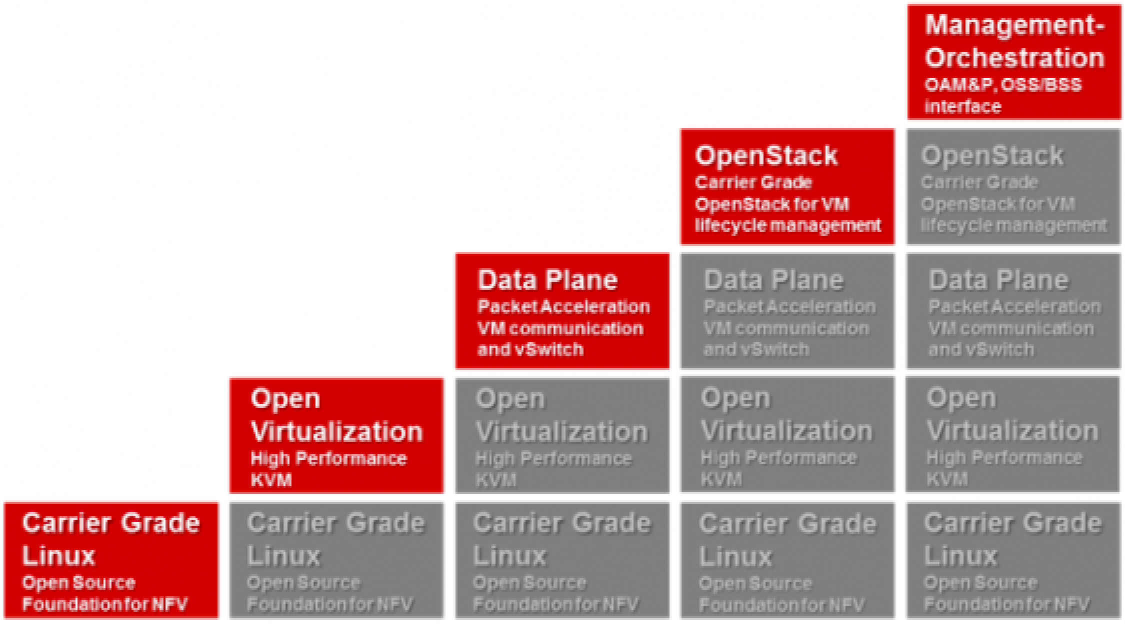
- Carrier Grade Linux (or other operating system)
- High performance virtualization
- Data plane acceleration, including high performance vSwitch support
- Integration with OpenStack
- Management and Orchestration layer with strong links to existing OSS/BSS systems

Other specialized software that may be required for NFV implementation includes DPI, firewalls, server load balancing, routing, and WAN optimization. For example, Qosmos, Procera, Saisei, Sandvine, and Allot offer DPI functions. Amartus, Ericsson, Amdocs, Openet, Oracle, HP, and Volubil provide software for policy, charging, and service assurance that can help link new NFV implementation to existing back office (OSS/BSS) systems.

Each of these layers can be supplied by different parts of the ISV ecosystem or integrated by one supplier. For example, VMWare, Microsoft, Redhat, Citrix, KVM, Wind River all provide hypervisors that offer server virtualization. 6Wind, Intel, Linaro, and MontaVista provide unique solutions to accelerate data plane performance.

A number of companies specialize in the development and implementation of carrier-grade middleware for network/telecom equipment, including Wind River, MontaVista, and ENEA. VMWare and Redhat are two leading IT suppliers that are enhancing their OS, middleware, cloud, and virtualization software to support NFV deployments.

Critical elements required for implementation of NFV in network elements


Management-Orchestration
OAM&P, OSS/BSS interface
OpenStack
Carrier Grade OpenStack for VM lifecycle management
OpenStack
Carrier Grade OpenStack for VM lifecycle management
Data Plane
Packet Acceleration VM communication and vSwitch
Data Plane
Packet Acceleration VM communication and vSwitch
Data Plane
Packet Acceleration VM communication and vSwitch
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(Source: Gigaom Research, Wind River)

Wind River

Drawing from its experience in the embedded and telecommunications industry, Wind River has created a modular portfolio of product solutions that can be used individually or in a combination to address each step of the migration to NFV or in combination to create a complete NFV host stack.

Wind River offers its Carrier Grade Linux (CGL) -registered Wind River Linux and Open Virtualization products to support the development of new NFV platforms and aid the migration of legacy applications to NFV. Open Virtualization is a real-time carrier grade virtualization solution using open source kernel virtualization machine technology to deliver systems with high performance with low latency rivaling native hardware performance.

Wind River Open Virtualization enables many applications and functions that run dedicated operating systems and hardware to consolidate into a single system. Open Virtualization also helps VM-to-VM communication by providing an optimized vSwitch based on the Intel© Data Plane Development Kit (DPDK). Open Virtualization supports secure containers, power management features, and live VM migration for the flexible provisioning of VMs without sacrificing performance.

The next building block in an NFV solution is a high-performance data plane. Wind River offers the Intelligent Networking Platform (INP) to help CSPs and equipment manufactures build high-performance, intelligent data plane solutions for packet processing and packet inspection.

The INP takes advantage of Intel's Data Plane Development Kit and advanced fast-path technology to achieve industry-best packet delivery to applications for wide range of virtualized applications. Integrated packet flow analysis and packet inspection provide critical services to applications such as security firewalls and intrusion detection.

OpenStack is cloud-based platform for orchestration and management of virtual machines and other virtualized resources. OpenStack is an open source based solution with considerable industry momentum behind it. Wind River is investing in OpenStack as a foundation for management of VMs and other system management functions. Wind River is developing carrier grade extensions to OpenStack to help CSPs and equipment manufacturers migrate their solutions to NFV.

Finally, Wind River, in conjunction with Intel provides a broad ecosystem of ISV partners and support for open NFV and SDN standards including Linux, KVM, OpenStack, OpenFlow and Open Daylight.

ENEA

ENEA's product suite includes:

- Enea Linux, which provides an open, cross-development tool chain and runtime environment
- Enea Hypervisor runs Enea OSE applications and provides semiconductor specific executive environments for bare-metal speed packet processing
- Enea Optima development tool suite for developing, debugging and profiling embedded systems software
- Element middleware software for high-availability systems

Enea has a global services operation offering end to end development and support for technology products.

MontaVista

MontaVista Software is a company that develops embedded Linux system software, development tools, and related software. It is a wholly own subsidiary of Cavium Networks (a leading supplier of networking silicon). MontaVista provides expertise in embedded devices and support of an ecosystem of middleware. MontaVista software solutions are deployed by leading Telecom Equipment Manufacturers (TEMs) that are building next generation routers, switches, security and application gateways, and 3G, 4G/LTE equipment.

Its Carrier Grade Edition (CGE) 7 Linux offers advanced virtualization features to enable seamless hardware acceleration for the NFV market. MontaVista is a major contributor to the Linaro.

Linaro

ARM and its partners have created Linaro, a non-profit engineering organization dedicated to open-source development of virtualization and networking middleware. Linaro has over 200 engineers including its internal staff and resources from its partners. It is working on optimizing the Linux kernel, security, and data plane performance. Notable Linaro supporters include MontaVista, ENEA, NSN, Cisco, and Huawei. Linaro offers its Open Data Plane to accelerate data plane performance and reduce latency across ARM, MIPs, and Intel platforms. Linaro also offers test and validation services.

VMware

VMware is enhancing its software defined data center products to meet the requirements of the network/telecomm industry. It offers a wide range of products including vSphere, vCenter, vCloudDirector, vCloud Automation, vCenter Orchestrator, and its NSX network virtualization software. VMWare supports OpenStack and multi-hypervisor environments. VMware is currently working with leading CSPs and NEPs, including NSN and ALU, on NFV implementations and proof of concepts.

VMware has the following goals for its platforms to enable NFV adoption.

- Provide efficient allocation of compute and storage resources, including high availability
- Offer a common platform for abstraction to virtualize key applications
- Enable a broad ecosystem of ISVs – including certification and automation

- Improve I/O in a VM environment; it will build on recent work to lower latency and increase throughput to VMs
- Provide support for dynamic service chaining among virtualized functions (leveraging NSX's ability to dynamically create logical topologies)
- Provide links to existing OSS/BSS systems

Red Hat

Red Hat is a leading provider of open source products including operating system (Linux), virtualization, cloud, storage, and middleware. In addition, it also provides a wide range of training, professional, and support services for its products. Best known for its Enterprise Linux products, Red Hat is promoting the use of its commercial open source software and services as a platform for NFV development. It offers the following products related to NFV:

- Red Hat OpenStack Platform
- Red Hat Enterprise Linux
- Red Hat Enterprise Virtualization
- Red Hat Storage
- Red Hat CloudForms
- JBoss Middleware
- OpenShift (PaaS)

Red Hat is working with a number of networking partners to develop NFV solutions, including Intel, Dell, Cisco, NEC, Alcatel-Lucent and Juniper. The company also offers a full range of professional and support services for its NFV software stack.

Outlook

CSPs face significant challenges over the next five years to develop new revenue generating services, retain current customers, and expand their network capacity to handle explosive bandwidth growth and to reduce the costs of delivering commodity services. Implementation of NFV technologies will enable CSPs to transform their networks to simultaneously introduce new services faster, reduce their costs of building new network capacity, and make network operations easier and less expensive.

Over the next few years, large SPs will explore and start to implement a range of NFV technologies on COTS platforms comprising a wide variety of use cases. Leading SPs are likely to evolve to NFV in a phased approach, including migration to COTS, virtualized applications, elastic capacity, and full stack orchestration.

Almost all Tier 1 SPs have voiced strong support for NFV technologies. These Tier 1 suppliers represent a majority of overall telecom infrastructure spending and their implementations will provide a significant boost to NFV market development. Within 5 years, NFV will be the main stream option for SPs deploying cloud and network architectures.

The driving force behind innovation and transformation in the telecom industry is the development of a broad based, independent software community. It is now up to the IT and networking industry to deliver the scalable, virtualized, multi-vendor software needed to make this NFV vision a reality.

In order the implement a broad range of applications on NFV, the industry will require a robust virtualization platform (OS) that can support telecom specific requirements, including 99.999 uptime, scale to 100 million+ users, provide high throughput, and low latency. This NFV platform must be secure and open – with the ability to tap into the broad range of IT and telecom applications to build systems with a wide range of performance and latency requirements.

Key takeaways

CSPs need to transform their networks to remain competitive and profitable in a highly competitive environment. NFV provides a roadmap to help CSPs rapidly introduce new services, scale their networks to handle increased bandwidth, and reduce their high operational costs. CSPs are currently trialing NFV in their labs as prove of concepts and a number will virtualize parts of their network during 2014. Over the next 5 years, NFV will gain momentum and will see significant adoption in the telecom network.

- CSPs need to carefully evaluate NFV in specific use cases (and part of their network) to ensure appropriately scalability, performance, and reliability.
- NFV will be deployed in stages over time. CSPs will move through the stages of virtualization, COTS, elasticity, and service chaining at variable timeframe (depending on their environment and specific applications).
- The creation of an NFV software ecosystem with independent software suppliers will be critical to the success of NFV innovation.
- CSPs will require telecom-grade virtualization software that provides scalability, performance, reliability, low latency, and strong security.

About Lee Doyle

Lee Doyle has 28 years of experience analyzing the IT, network, and telecom markets. Previously, he was general manager for network, telecom, and security research at the International Data Corporation (IDC). Doyle Research delivers quantitative and qualitative analysis, forecasting, and market-positioning advice to network and IT industry vendors, CSPs, and financial analysts.

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