BUSINESS BRIEF

Network Transformation
NFV

How Open Source Software Speeds NFV Adoption in the Carrier Network

As Communications Service Providers (CoSPs) deploy Network Functions Virtualization (NFV) systems in their networks, they need to accelerate their time to business value through the use of open source software

"Intel is committed to helping CoSPs deploy NFV systems; ensuring that the required software is available, that vendors have compatible products in the market, and that staff have the information, training, and tools they need to build effective solutions."

Telecom infrastructure for software-enabled services is being standardized in open source

Communications Service Providers (CoSPs) can see the business opportunities created by innovation based on Virtualized Network Functions (VNF). Building on architectures originally developed for cloud services and now adopted in the enterprise, recent Network Functions Virtualization (NFV) innovations support the service assurance, performance, and fault management requirements of the CoSP network. While the high-level industry standards supporting these use cases have been documented by the ETSI NFV industry specification group, the pragmatic details are being determined through various open source software initiatives.

There are multiple software initiatives in NFV, from data plane to service design and fulfilment. The Linux Foundation* has been active in bringing these together in an overall systems architecture that leverages the economy of scale available from the network, enterprise IT, and cloud services markets[1].

Many organizations are involved in these open source initiatives as the market evolves, committing significant software development resources. One of the benefits of this approach is the number of people actively engaged who can spot and remedy software errors. With a broad understanding of "how the code works", integration issues between modules can also be addressed quickly.

While some proprietary implementations of NFV are available, the leading vendors are engaged with open source developments for their NFV products, with Cisco*, Ericsson*, Huawei*, Juniper*, Nokia*, RedHat*, Samsung*, VMware*, and ZTE* all being governing members of the Linux Foundation Networking Fund.

CoSPs must understand and evaluate the use of open source software, and the associated supply chain for their network infrastructure; balancing the rapid time to market available, with the rigorously tested proprietary platforms classically provided by Telecom Equipment Manufacturers (TEMs).

At the infrastructure level, open source components are available for the operating systems and associated management stacks. CoSPs can consume these directly, but would generally seek a distribution from a vendor with support available.

At the VNF level, if a potential software innovation is identified, CoSPs can rapidly mount a limited market trial on existing infrastructure. If successful, CoSPs can

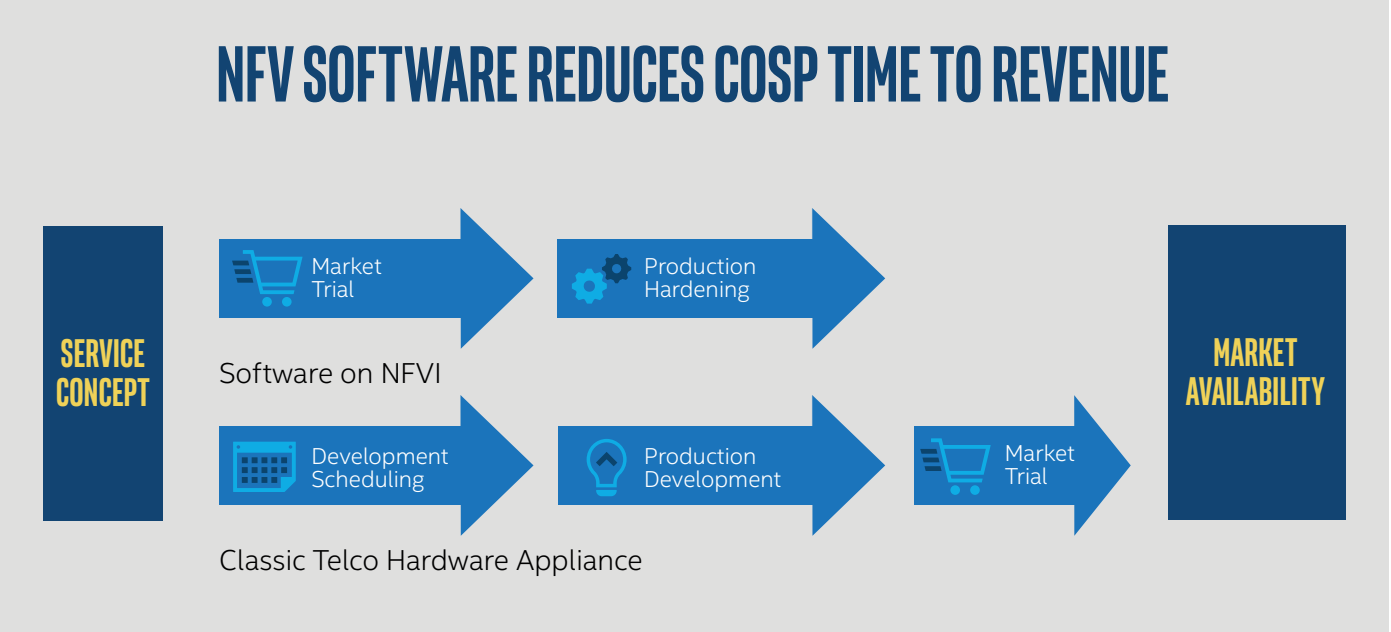

Figure 1. NFV Software reduces time to market

then invest in hardening the software for production use at scale, as shown in Figure 1.

This contrasts with the classic Telecommunications Equipment Manufacturer (TEM) scenario, where on identification of a potential innovation, time is consumed getting the product development agreed and scheduled. The product would then be built, thoroughly tested, and support facilities developed before the device is made available to the CoSP to determine if the innovation is actually worthwhile in the market.

Use of open source software therefore gives flexibility in supply, rapid time to market trial, and testing undertaken by the community.

Software enablement provides business flexibility

NFV separates the hardware infrastructure from the software applications used to perform network functions, using IT industry standard practices. CoSPs can introduce new components sourced from the open market to differentiate their service offerings and bring them to market in their own timescales. This contrasts with executing those same functions in appliances created by TEMs, with highly optimized integrated solutions, and with lengthy timelines under the control of the TEM rather than the CoSP.

CoSPs building NFV systems are using software components in three separate domains: Infrastructure Virtualization, Management and Orchestration (MANO) systems, and the actual VNFs. Having split the system into various modules for flexible procurement, integration is then required to assemble a complete system to suit a CoSP's specific needs.

The source of the integration resources is also under the CoSP's control. Various organizations can undertake this activity, such as TEMs, independent Systems Integrators, or the CoSP's own in-house development teams. If future flexibility is required, the integration needs to ensure that open interfaces between the modules are maintained to allow the simple evolution with new or replacement modules.

At the Network Functions Virtualization Infrastructure (NFVI) layer, virtualization is very similar to the environment used inside CoSPs' IT organizations. Existing IT skills and platforms can be redeployed to support NFV requirements, and deliver an economy of scale for the business. While the IT department will be used to working with servers in their data centers (or using a similar infrastructure as a service offering from cloud providers), the same application environment can also be made available in equipment designed to operate in network node sites such as central offices and street cabinets, or even as Customer Premises Equipment (CPE). Many CoSPs are using variants of the Linux KVM operating system to create a consistent, flexible application environment across their network estate, as an alternative to the proprietary virtualization environments already used in their data centers.

Operating the resulting infrastructure can be achieved using the software from the OpenStack suite of open source management initiatives, with 39 projects involved in the 17th "Queens" release in February 2018. These have been extended beyond their inception as cloud services and enterprise IT tools to handle carrier requirements, as an alternative to proprietary offerings. These management software modules are being complemented by NFV specific resource and service orchestration open source developments from the

ETSI Open Source MANO (OSM) and Linux Open Network Automation Platform (ONAP) groups; along with various other initiatives. Using these modules enables CoSPs to achieve overall operational efficiencies by consolidating software management across network and IT cloud domains.

The industry is also starting to re-engineer traditional VNF applications as multiple cloud native microservices. This allows better alignment with cloud services practices, such as dynamically scaling infrastructure usage to handle actual traffic loadings and minimize energy consumption. Microservices also minimize the amount of software integration needed to introduce a new service feature, enabling in-service software upgrades for CoSP production networks.

CoSPs are also starting to use DevOps practices from the IT world to handle the increased rate of change available for the production network infrastructure and VNFs. This enables them to handle timely, incremental software updates in the network operations center, rather than infrequent and time-consuming platform upgrade cycles historically used for major network upgrades.

Using software-enabled networks to deliver NFV will improve business flexibility. However, to achieve this, CoSPs must bring together people, processes and platforms from the CoSPs' network and IT organizations.

OPNFV* establishes open source standards for NFV platforms

One of the key features of software-enabled networks is the continuous stream of innovation that is being provided by vendors across the industry, with a multitude of open source working groups. A key resource for CoSPs is the Linux Foundation's Open Platform for NFV* (OPNFV*) initiative. Through cross-community continuous integration, it brings together the various component streams and proves their interworking. The scope of the activity covers open standard hardware, operating systems, Input/Output (I/O) and switching features, network controllers, resource and service management, as shown in Figure 2.

The fifth Euphrates release in November 2017 was spread over 52 coordinated projects, incorporating 5772 merged software patches by 197 developers from 22 organizations[2,3]. Through system level integration, deployment and testing, OPNFV creates a reference NFV platform to accelerate the transformation of service provider networks. Industry standard testing methods are published, and the resulting platform is documented as a release every six months.

With the ever-increasing rate of change, specifying systems for procurement is increasingly related to the software versions in the absence of fully documented industry standards. OPNFV also has a verification program to check compliance of vendors' products with the releases, using automated tools that can be operated by test labs and other organizations.

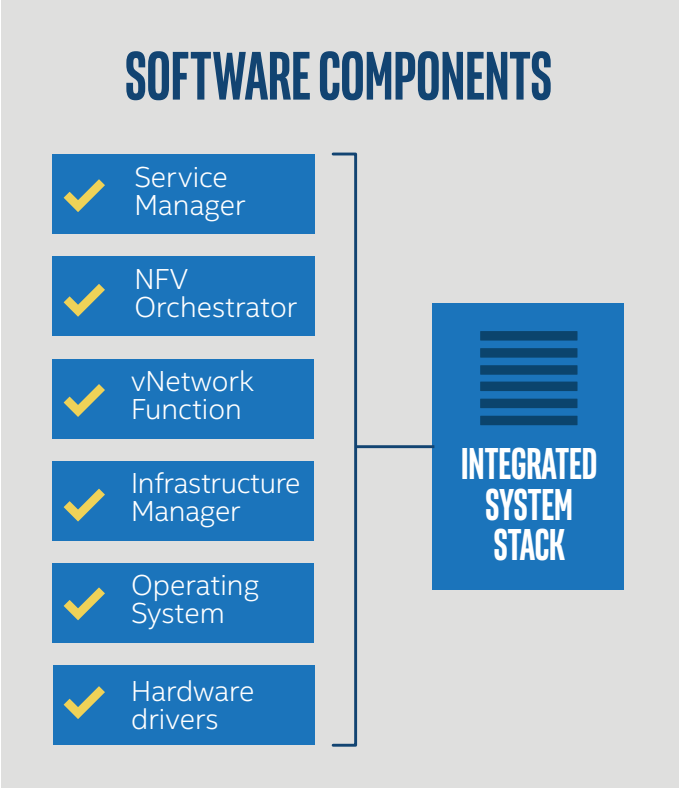

Figure 2. Integrated software system stack

By taking advantage of OPNFV activities, CoSPs can benefit from seeing the consolidated industry direction and anticipate the NFV system features that are likely to be available soon. This simplifies high level procurement by removing the need for involvement in the various tributary open source initiatives.

At a lower level, CoSPs can use OPNFV outputs to create their own testbeds using industry standard tools. They can also use test suites and benchmarking results for performance criteria in competitive procurements, or seek vendor products that meet the verification standard.

OPNFV inititaives enable CoSPs to accelerate deployment by ensuring component interoperability, reducing adoption risk, decreasing time to qualify NFV building blocks, and alleviating integration challenges when using a blend of open source and commercial products.

Enabling transformation

Intel works closely with leading CoSPs to evolve their NFV systems, making results available from proof of concept trials of new technologies through publication of reference architectures. Intel also identifies required software features, and then makes contributions across the NFV open source value chain; from Data Plane Development Kits (DPDK) and Fast Data Input/Output (FDio) to achieve carrier-grade levels of data plane performance with standard servers, to the ETSI OSM and Linux Foundation ONAP projects to simplfy interworking with CoSPs' Operating Support Systems (OSS).

Intel ensures that CoSPs can access the tools available to make best use of the evolving features in the microprocessor systems.

These developments also leverage initiatives in the enterprise IT and cloud services markets, enabling consolidation across the CoSP's network and IT platforms for operational efficiencies.

The scale of Intel's commitment is indicated by the technical leadership roles undertaken in various open source communities, which are generally as a result of the level of software contributions made.

Intel also works closely with hardware and software vendors to develop their products to meet CoSPs' main NFV use case requirements. A good example is the Intel® Select Solution for NFVI, where Intel has developed a reference architecture for standard servers, including the hardware and OSS. It then published the associated performance benchmark, and worked with the vendors to develop commercial products. CoSPs can procure infrastructure servers in the knowledge that they have been verified to deliver a level of performance that does not require further testing, enabling competitive supply and reducing overall time to market.

Intel also works closely with software vendors, systems integrators, and others developing VNFs as part of the Intel® Network Builders ecosystem. Over 260 companies are involved, and their products are displayed in the online Network Builders solutions catalog along with solution briefs and reference architectures for NFV use cases. This enables CoSPs to gain an understanding of products they might want to consider from across the open market when assembling an open NFV system.

CoSPs wanting to transform their networks will need to upskill technical staff to understand how to work with software-based NFV systems. The Intel® Network Builders University provides a portfolio of multilingual training courses about the technologies. This can be linked into a CoSP's learning management system so that staff engagement and test results can be monitored.

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Solution summary

CoSP service innovation and speed to value will be maximized by open software-based systems. The Linux Foundation's OPNFV initiative brings together the necessary component parts in an integrated release program. This can either be consumed directly by CoSPs, or used as the basis for competitive procurement from a variety of industry vendors.

Intel® technology foundation

Intel® Xeon® processors form a key foundation for NFV systems, and are complemented by Intel's support of numerous open source software initiatives across the industry to give the greatest flexibility to meet CoSPs' evolving service requirements:

- Intel® Xeon® Scalable processors are designed to meet the needs of data-intensive communications and 5G networks, optimizing workloads for compute, network, and storage and featuring amazing performance, security features, and agility. The Intel Xeon Scalable processor can help CoSPs support more connected devices, rapid service innovation, higher data rates, and subscriber density with very low latency
- Intel® Xeon® D-2100 processor is a ground-breaking data center processor architecture in a form factor optimized for network, storage, and cloud edge solutions. It supports increasing endpoint demand, optimizing infrastructure, and capacity at the edge, providing excellent performance-per-watt in constrained operational space and power requirements.

Find the solution that is right for your organization.

Visit **https://intel.com/network** to learn about the path to 5G, or **https://networkbuilders.intel.com/** to get started with NFV now.

[1] Linux Foundation, “Harmonizing Open Source and Standards in the Telecom World” White paper, May 2017

[2] OPNFV Presentation, “An Introduction to OPNFV”, February 2018

[3] OPNFV Report, “2017 OPNFV Year In Review”, February 2018

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