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Virtualized EPC: Unleashing the potential of NFV and SDN

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Virtualized EPC: Unleashing the Potential of NFV and SDN

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Abstract

Software Defined Networking (SDN) and Network Function Virtualization (NFV) have exploded over the telecom technology horizon in the past couple of years, surprising many with the speed at which the interest has evolved and spread. It is important to note that this is the culmination of a long effort to break up vertical proprietary stacks in telecom technology. The principles underlying both have begun to appear in some form in network standards and software over the past three to four years, priming the market for this major change.

SDN is an architectural concept that encompasses the programmability of multiple network layers – including management, network services, control, forwarding and transport planes – to optimize the use of network resources, increase network agility, unleash service innovation, accelerate service time-to-market, extract business intelligence and ultimately enable dynamic, service driven virtual networks.

This idea was foreshadowed in IP Multimedia Subsystem (IMS) and the architecture it inspired, in which the three layer model of data plane, control plane and applications plane set out in SDN is also present. The key idea behind IMS was modularization of network functions so that operators could buy best-of-breed product for each function. SDN effectively takes this one step further.

NFV, on the other hand, aims to address various problems by leveraging standard IT virtualization technology to consolidate many network equipment types onto industry standard high volume servers, switches and storage, which could be located in Datacenters, Network Nodes and in the end user premises.

Software Defined Network (SDN)

Software Defined Networking or SDN is a technological approach to designing and managing networks that has the potential to increase operator agility, lower costs, and disrupt the vendor landscape. Its initial impact has been within leading-edge data centers, but it also has the potential to spread into many other network areas, including core public telecoms networks.

SDN has already had a significant impact on the networking industry, evidenced by over \$2Bn M&A investment, vibrant start-up activity, the formation of 'Open' industry initiatives, adoption by a significant number of incumbent networking equipment vendors, and use by leading-edge cloud players such as Google.

What is SDN?

Conventionally, networks are built using devices that make autonomous decisions about how the network operates and how traffic flows. SDN offers new, more flexible and efficient ways to design, test, build and operate IP networks by separating the intelligence from the networking device and placing it in a single controller responsible for the entire network. Taking the 'intelligence' out of many individual components also means that it is possible to build and buy those components for less, thus reducing some costs in the network. Building on 'Open' standards should make it possible to select best in class vendors for different components in the network introducing innovation and competitiveness.

SDN started out as a data center technology aimed at making life easier for operators and designers to build and operate large scale operations. However, it is now moving into the Wide Area Network and could offer operators the ability to delay purchase of additional networking capacity by making better use of the existing infrastructure.

Benefits of SDN

At this stage of the market, hard and fast numbers are difficult to come by, though in theory SDN offers:

- § Better utilization of network assets such as LAN & WAN links, interconnects and networking equipment leading to improved margins.

- § Lower operational costs as the network can be managed from a central point rather than by each device or multiple dedicated consoles. Better use can also be made of existing links by increasing their utilization.

- § The ability to test and deploy new services faster.

- § The network becomes a programmable entity allowing its use and capabilities to change according to demand and the needs of the applications that sit on top of it.

Google were one of the first companies to announce it had moved its data centers and Wide Area Networks (WANs) to SDN claiming improvements in data center computing performance as well as a 60% to 70% improvement in WAN utilization.

With SDN, service providers could offer business users new services such as network capacity and other resources on demand allowing the business user's applications to control or occupy a pre-defined portion (virtual network) of the service provider's network. Contrast this level of flexibility with the rigid point to point services that are on offer today.

SDN could also offer advantages to mobile operators in managing the Radio Access Network and the associated backhaul networks by allowing the operators to specify different paths for different traffic types and matching the needs of the data to the capabilities of the network. Several vendors have been working on more complex use cases that exploit the concepts of STL Partner's two-sided business model.

An example might be a user who rents a movie from iTunes, Netflix or Amazon. Today the service provider simply delivers the data to the end user using best effort. But what if the application (iTunes) could tell the network that this is a video stream and requires a specific level of bandwidth with low delay and jitter for a specific amount of time? The network could then set up a path for the duration of the video with the user paying a little extra for a premium rate service. Contrast this with the situation today where there is no control over the user experience and there can often be loss of quality, delays or pauses in transmission while some part of the network buffers the data stream due to congestion or low priority. Clearly the service provider would need a direct connection to the content owner in order

to provide such a service, but in this use case, the service provider is receiving revenue from the user and the content owner.

SDN is moving into the Wide Area Network allowing service providers to deliver new services where for example, the network is matched to the needs of the traffic. Service providers have used a technology called Multi Protocol Label Switching (MPLS) for many years for both their own internal networks and for services they offer to enterprises. SDN could replace MPLS with a richer network fabric that offers the service provider the advantage of better utilization and therefore lower operating costs and delayed capital expenditures.

Operational Benefits

Key operational benefits include:

- § Networks recover faster after reconfiguration or network outage
- § Better utilization of core network assets
- § Lower energy and cooling needs
- § Simpler management
- § Better integration with virtual computing
- § Faster to test and deploy new networks

There have been several deployments of SDN, largely as Data Centre technology to integrate networks more effectively with Virtualized Computing. Virtualized Computing has dramatically reshaped the hosting market, is the foundation of cloud computing, and works by allowing physical server to run multiple operating systems, thereby raising server utilization from around 10% to over 90%. This can increase performance, reduce operating costs and deliver computing power/storage on demand.

Additionally, SDN can overcome certain limitations of existing networking equipment and network operation that have been holding back the development of Virtual Computing by driving up costs.

Network Function Virtualization (NFV)

The European Telecommunications Standards Institute (ETSI) Network Functions Virtualization (NFV) Working Group (WG) was formed by a group of 13 telecom network operators seeking a network ecosystem with the advantages of the IT ecosystem. This culminated in the publication of the white paper “Network Functions Virtualisation” in 4Q 2012 and the formation of the ETSI working group.

The consortium has long noted the scale economies of the IT ecosystem built on the Intel x86 architecture and that a large part of the purpose-built and proprietary network and telecom hardware is also built on the Intel x86 platform. The differentiating values are the system architecture, software,

service, and packaging. This observation of the widely used platform leads to the question of why not use IT ecosystem hardware with the greater economies of scale and quicker technology-upgrade cycles.

How does NFV relate to SDN?

NFV is complementary to SDN though neither is dependent on the other. SDN virtualizes the control of the network and NFV virtualizes individual network applications or functions. Both can exist without the other, but working together SDN Controllers would manage the configuration and deployment of NFV functions in a virtual network.

This concept is shown in Figure 1 – Network Functions Virtualized and managed by SDN. On the left a number of dedicated appliances can be seen. Each is performing a specific network function and all of them are being managed by a SDN controller. On the right the functions have been virtualized and are running on a standard server platform, the functions are still managed by the SDN controller, but the overall cost of deploying and maintaining the specific network functions has been reduced by using the NFV approach. NFV will supplement the efforts of the SDN community by reducing the cost of deploying and running network functions and making them available as applications on a virtualized platform. The danger for many vendors of dedicated appliances is that some of these functions will become available as Open Source software threatening vendor revenues.

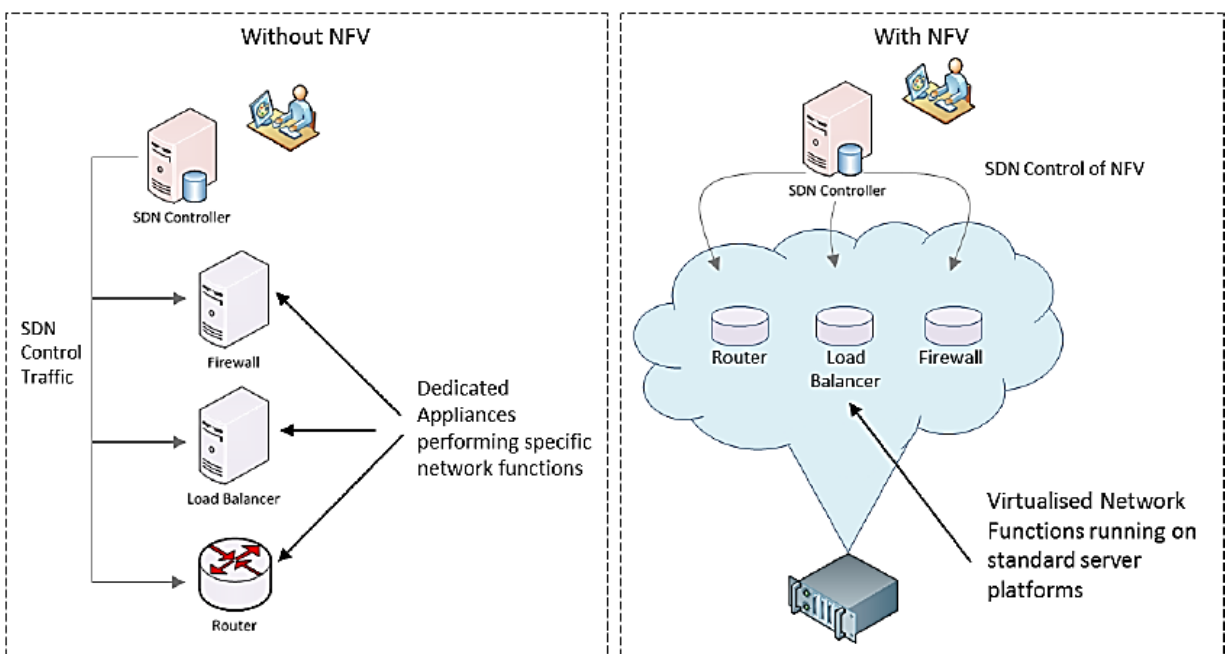


Figure 1: Network Functions Virtualized and managed by SDN

Why SDN and NFV?

The NFV white paper identified several benefits that operators can achieve by virtualizing their networks. First on the list is - “Reduced equipment costs and reduced power consumption through consolidating equipment and exploiting the economies of scale of the IT industry.”

The telecom operators rightly observe that the IT industry has much larger economies of scale and the ETSI NFV WG seeks to benefit from that scale. As an example, consider that the IT industry market is on the order of 10 million servers per year and overall IT spending is on the order of \$1.7 trillion. For comparison, the core network market for wireless infrastructure is about \$22 billion. Faced with declining revenues, operators seek to drive out cost where possible, and the economies of scale of the IT industry are an attractive pull to a different business model.

In the bigger scheme of things, operators are looking for a solution that will “move the needle” or make a notable difference in the overall financial result. NFV will be a significant contributor to the overall picture, but this must be considered in the light of what can be virtualized and its value in the overall financial picture. To develop business case for SDN & NFV three portions of the mobile broadband network and prospects for virtualization can be considered:

- **Data Centers:** Using commercial IT hardware.
- **In-line Service Chaining:** Blending proprietary, purpose-built, and commercial IT.
- **Evolved Packet Core:** Consisting largely of purpose-built hardware.

The data centers follow the trends in the commercial IT market and will be virtualized at the operator’s discretion, which is not the subject at hand. The other elements are essential parts of the network and much of the in-line service plane chaining is already, or soon will be, virtualized.

Migrating the Evolved Packet Core (EPC) to commercial IT must be considered with respect to the EPC market, which was \$1.8 billion in 2013. If this were to be virtualized on a white box network, then hardware savings of around 20% to 30% might be achieved, but other cost impacts would offset this. While 20% of \$1.8 billion is a significant amount, the operator will not capture all of that, and it is certainly not enough to make a notable change to the overall financial picture.

Virtualized Core Telecom Network

In a research report by ABI Research market forecast for virtualized core network equipment is expected to reach nearly \$6 billion by 2018 by addressing services plane chaining, IMS, VoLTE, and, finally, the Evolved Packet Core (EPC). The most likely candidates for virtualization are applications that fit well into a server architecture for the control and services planes, rather than performance-driven packet processing of the data plane. The EPC will eventually virtualize, but will materialize later for reasons of expedience and financial considerations, such as depreciation of newly deployed 4G networks. If commercial IT or white box platforms capture these market segments, then the value of the hardware components from a commercial IT deployment can be reduced by 20% or more. The large operators have already built significant data centers. The operational experience and economies of scale give them an advantage, should they opt for commercial IT or white box platforms to host SDN/NFV.

Virtualized Evolved Packet Core (EPC)

The key to enabling successful virtualization of each EPC component is to deliver good networking performance and maintain virtual machines (VMs) isolation. This section of the paper introduces the concepts that are continuously being refined to successfully implement a virtual EPC.

This section of the paper will describe how virtualized EPC can be deployed on an Intel architecture server platform to overcome network virtualization challenges using the Intel® Data Plane Development Kit (Intel® DPDK) and achieve the carrier grade service on a common Intel architecture server platform.

As traffic keeps growing – by as much as ten times in five years – network operators are addressing this demand with continual investments in network appliances. However, this additional equipment requires more space, and the growing varieties of hardware are increasing complexity for operators building up capacity, enhancing performance and replacing equipment at end of life, which happens sooner as technology innovation accelerates.

As discussed earlier, virtualization technologies can help reduce the complexities caused by diverse hardware by running vendor applications on common commercial, off-the-shelf (COTS) hardware. In addition, the performance and capability of each application can be dynamically adjusted to satisfy changes in demand. Some of these benefits were highlighted in ETSI's Network Functions Virtualization (NFV) forum activities, where major global network operators gathered to discuss how to realize such solutions. The solutions are expected to significantly reduce CAPEX and OPEX for operators by simultaneously simplifying capacity management and enhancing network capacity.

In the architecture for virtualized EPC the individual functions for each EPC node (e.g., Mobility Management Entity (MME), Packet Gateway (P-GW) and Serving Gateway (S-GW)) runs in a virtual machine (VM). Each virtualized function is allocated to a VM. Each VM is totally isolated from the other VMs and runs independently of the other VMs' required performance. However, all the VMs in a logical node mutually interconnect in order to forward packets correctly. The details of the implementation will be discussed in a later section.

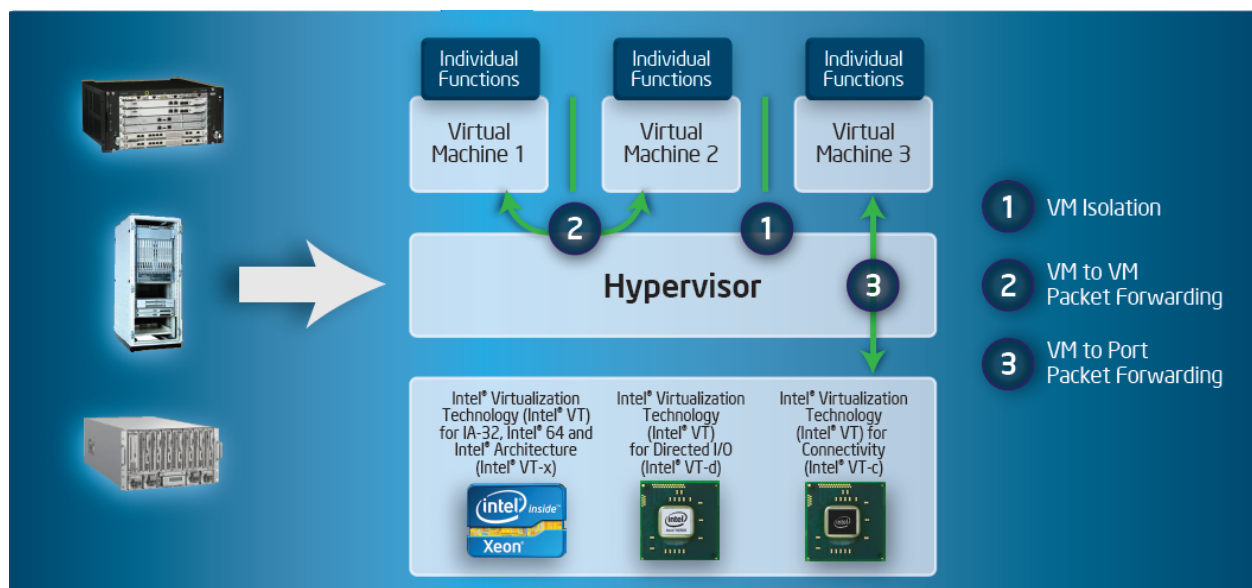


Figure 2: Virtualized Network Functions

SDN, which plays a complementary role to network virtualization, facilitates the abstraction of network infrastructure. As a result, network operators can control virtualized network resources across network applications, service types, application types, service providers, etc. by orchestrating various networks from the transport to the application network. The bandwidth and capability of each function can be changed dynamically based on requested application or service, or current demand.

SDN will enhance virtualized network capabilities to monitor and manage VM status, and control the scaling (out/down) of each VM according to the performance and capability demands across multiple services, tenants, applications, etc. Conversely, network virtualization will maximize the benefits of SDN orchestration through its native ability to provide on-demand flexibility and hardware independence.

LTE Core network architecture has fundamentally changed from 2G/3G, and it has shifted to a flat architecture that directly manages each base station (i.e., eNodeB). Simplistically, a MME could represent a busy controller of mobility-related signaling traffic, and a S-GW and a P-GW are likely to focus on data plane (DP) processing. But in reality, their functions are more complex since the S-GW and P-GW also play a vital role in the control plane (CP), handling functions such as inter-eNodeB mobility anchoring.

Since the naissance of the smart device, mobile network carriers have been facing challenges in expanding performance and enhancing capacities to adapt the network to satisfy the needs and demands of users who expect the LTE experience to be similar to fixed lines or WiFi services. For instance, planning, configuring and tuning the network to handle surging and fluctuating traffic are becoming more complicated. Furthermore, M2M services kicking into high gear in the mobile network will create a new nature of traffic. Network node deployments and configurations could go beyond recognition or financial sense, considering the need to keep up with the traffic using EPC systems bound on static capabilities and a non-flexible performance balance between Control Plane (CP) and Data Plane (DP).

It is becoming essential to have elastic network performance and capabilities, as well as flexible performance balance between CP and DP in order to dynamically handle such traffic fluctuations. Obviously, carrier-grade quality, together with the necessary performance and capabilities, is fundamental to the mobile network.

Business Case for SDN/NFV

Significant amounts of CAPEX are involved with any network deployment, but it is useful to see how important it is for an operator, relative to other financial items. The example taken here illustrates selected financial items from the Verizon Communications annual report and Verizon Wireless financial reports.

Verizon Wireless had a CAPEX of nearly \$9 billion in 2012. This includes all CAPEX – towers, radios, trucks, capitalized software, and its new LTE network. Given that Verizon Wireless may spend \$20 billion building out its LTE network over a multi-year period, a reasonable estimate is that about \$4 billion of its yearly CAPEX is for the LTE network. The core network equipment could be \$500 million. If a deployment like this were to use a virtualized network with commercial IT equipment (and assuming the

network software was available), a deployment like this might realize \$100 million in core network equipment savings.

While \$100 million is a lot of money, it is only 0.3% of EBITDA. From the operator's perspective, \$100 million is a lot of savings, but hardly game changing to the financial picture, so hardware cost savings cannot be key drivers for SDN/NFV. Rather, the opportunities are with the fundamental changes to business processes that drive costs out of the OPEX and the competitive advantages of accelerating the generation of new business opportunities.

Opex savings and Revenue Generation

Recurring OPEX savings could occur year after year by addressing OPEX-intensive tasks like:

- Eliminating test lab facilities for interoperability testing
- Eliminating the take down and provisioning of network upgrades and additions
- Eliminating physical boxes and cable migration
- Incorporating special virtual networks and debugging on live hardware in real time

Other ways that SDN/NFV could improve OPEX and revenue generation include:

- Rapid prototyping
- Rapid network reconfiguration and customer moves or changes
- Rapid provision of new services, facilities and customers
- Capacity on demand for dynamic traffic peaks
- Offloading to commercial SDN partners and suppliers
- Providing telecom apps with more visibility into the network

Conclusion

SDN and NFV are shaping up to be the biggest paradigm shift in the telecom industry and will follow and leverage the changes happening in the IT community. The telecom industry has migrated into the digital age and, with the advent of all IP 4G LTE, the morphing of telephony into mobile broadband is profoundly affecting all aspects of the industry, including consumer behavior. The telecom processes are compute-intensive and the inevitable merging of telecom and IT will only accelerate until the mobile network resembles a distributed super computer with radio heads attached at the cloud's edge.

We are in the early stages of a long-term transition to SDN/NFV architected networks; a lot will be learned as each year passes. Carriers will learn that some avenues are not as fruitful as expected, and telecom equipment manufacturers and software suppliers may well invent new approaches that open up new applications.

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