

# *SDN AND NFV:* The Path Forward for Broadband Access

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*Software Defined Networking (SDN) and Network Functions Virtualisation (NFV) are creating more open, programmable and scalable networks with far reaching implications. Service providers are embracing both operating models to unlock legacy hardware-centric architectures and move towards enabling an open framework of revenue-generating, cloud-based software applications.*

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## Introduction

Today's broadband access provider faces a challenging task. Changes in customer behaviour and expectations create both downward pressure on traditional revenues, while also illuminate significant opportunities for new service delivery. No longer reliant on legacy services that drove reliable revenue streams for operators, customers now embrace a digital lifestyle with unpredictable business models. To adapt to this changing environment, service providers must too embrace a new approach – one that embraces rapid and agile service delivery driven by a dynamically changing marketplace.

To that end, service providers are looking to Software Defined Networking (SDN) and Network Functions Virtualisation (NFV) to evolve their broadband access network. These complementary operating models streamline network operations in an increasingly complex interconnected web scale environment, while enabling the evolution of business models to thrive in a customer-facing, app-focused marketplace. They also position service providers to leverage and effectively manage the double-digit growth factors posed by the emerging all-digital landscape. By embracing these technologies, service providers are joining an open network ecosystem that is fuelling abundant, continuously evolving opportunities for all involved, while realising the future of networking.

## SDN and NFV Background

SDN and NFV were created out of the desire to gain flexibility and programmability in existing networks that would enable the timely creation and deployment of new applications and services in days or weeks, as opposed to months or years.

SDN was devised by researchers who were frustrated by the need to upgrade or change out software in network hardware devices every time they wanted to try something new. They introduced the idea of programmable, centralised control of the network and its elements. To achieve this capability, they separated control and forwarding functions from the network and used well-defined interfaces to enable programmable behaviour of the network and its elements. SDN initially proved its great value in cloud data centers<sup>1</sup>. Today, the Open Networking Forum is in the early stages of an effort called Central Office Re-Architected as Data Center (CORD), which uses SDN, NFV and Cloud to deliver data center economies of scale and cloud-style agility to service provider networks<sup>2</sup>.

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<sup>1</sup> SDxCentral, NFV and SDN: What's the Difference," <https://www.sdxcentral.com/articles/contributed/nfv-and-sdn-whats-the-difference/2013/03/>

<sup>2</sup> Open Networking Forum, "CORD Highlights" <https://www.opennetworking.org/images/stories/downloads/showcase/2015-6/CORD-Slides-ONS-ONF-June-11.pdf>

NFV was created by a consortium of service providers who saw the need to make changes to their networks to support quick deployment of new network services and improve their profit margins in the process. Standard IT virtualisation technologies inspired them to virtualise network functions to rid their networks of clunky hardware appliances that slowed both innovation and provisioning. To develop standards to speed NFV's emergence across as many networks as possible, service providers also worked with the European Telecommunications Standards Institute (ETSI). The group established the NFV's basic requirements and architecture<sup>3</sup>.

While each technology is distinct, SDN and NFV work well together to empower service providers to unchain themselves from slow and costly legacy architectures. For their efforts, service providers who implement both technologies enjoy CapEx and OpEx benefits as well as the ability to keep up with the pace of innovation and grow new revenue. (Figure 1)

Working side by side, SDN and NFV also enhance and make possible important aspects of future networks, including:

- Ubiquitous fibre connectivity
- Multi-service points
- Automation, virtualisation and programmability
- New user-defined services

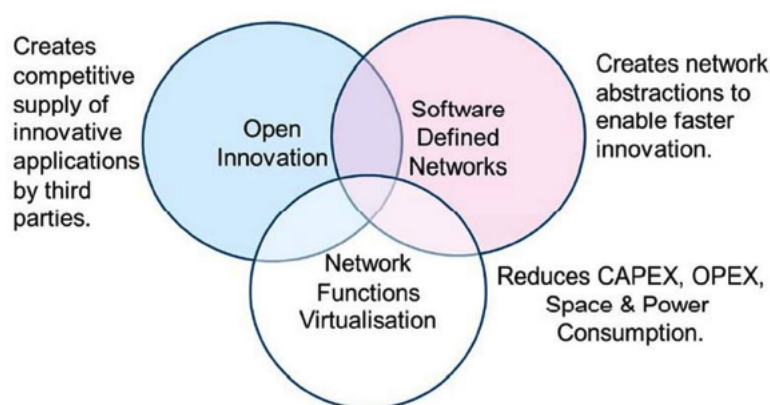


Figure 1 - NFV Relationship with SDN  
(Source: SDxCentral, NFV and SDN: What's the Difference)

<sup>3</sup> SDxCentral, NFV and SDN: What's the Difference,"  
<https://www.sdxcentral.com/articles/contributed/nfv- and-sdn-whats-the-difference/2013/03/>

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## Data Centre to Access Network Path

SDN and NFV made their initial mark in data centres. Their high-bandwidth, cloud-centric applications demanded robust, yet agile, user-driven networks to support rising demand for enterprise cloud computing, video streaming applications, social media, Internet of Things (IoT), the dramatically rising use of smart phones for all of the above and much more. The two technologies enabled data centre operators to envision the future as they disaggregated their monolithic, proprietary systems in order to implement highly automated, programmable, and software-centric open networking architectures in data centre environments.

The streamlined networks provided consistent, high-quality-of-service experiences for data centre customers and their end users. Meanwhile, Web 2.0 cloud services providers were finally able to create differentiated services for their customers without suffering the usual high overhead and prolonged time to market.

Recognising the impact this shift could have on the broader network, service providers began to implement SDN and NFV into their legacy public networks. While a long-term effort, service providers see the benefits of moving towards future networks as soon as possible. In addition to hardware, they are using SDN and NFV to remove the vast number of vendor and device-specific application programme interfaces (APIs) from their transport, access, and CPE Operations Support Systems (OSSs). By dismantling their legacy network management and OSS silos, they are clearing a path for cost savings and new opportunities their old networks would be unable to support.

Some providers are well on their way to virtualising their networks. At the 2015 Open Networking Summit (ONS), AT&T committed to virtualising five percent of its network by the end of the year. The carrier announced at the 2016 ONS its commitment to virtualising 30 percent of its network by the end of 2016 and 75 percent by 2020<sup>4</sup>. Verizon officially launched its virtualisation journey in 2Q 2015<sup>5</sup>.

## Service Provider Transition

By deploying SDN and NFV in their networks, service providers are transforming their business models to embrace today's "app culture" wholeheartedly. As they update their networks, they are in an increasingly better position to anticipate and meet the rapidly changing demands of their customers and respond to ever-shifting market dynamics.

Their ability to implement and programme "virtualised customer premises equipment (CPE)," which does not need to be physically installed, maintained, or amortised, gives them a host of new options. For example, service providers can choose best-in-class suppliers and implement or replace solutions as needed. They can also work with third parties for apps, services and outsourcing of network operations, or, insource software development.

Future networks reflect the reality that focusing on customers instead of the limitations of legacy networks is the more profitable business model. Future networks allow customers to determine which apps are on top, how long they thrive and how quickly they emerge. By architecting their networks to respond to customer needs, service providers also are better able to balance service velocity with what are sure to be unprecedented network growth rates. For example, instead of spending a disproportionate amount of time and resources on implementing large and infrequent software releases, service providers can switch to more manageable and cost-effective micro software release schedules.

### Open Networking

SDN and NFV are not emerging in a vacuum. The era of open networking has wide ranging support in the form of standards, collaborative projects, and organisations that reflect the continued convergence of the communications and computing industries. Some of the driving forces in open networking include:

- **OpenFlow** - The first standard communications interface defined between the control and forwarding layers of an SDN architecture; OpenFlow allows direct access to, and manipulation of, the forwarding plane of physical or virtualised network devices such as switches and routers<sup>6</sup>.

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4 Enterprise Networking Planet, "AT&T to Virtualize 75 percent of its Network by 2020", <http://www.enterprisenetworkingplanet.com/netsp/att-pledges-to-virtualize-75-percent-of-its-network-by-2020.html>

5 eWeek, "Verizon Outlines Plan to Transform Network with SDN", <http://www.eweek.com/networking/verizon-outlines-plan-to-transform-network-with-sdn.html>

6 Open Networking Foundation, "Open Flow" <https://www.opennetworking.org/sdn-resources/openflow>

- **Open vSwitch** - This production quality, multi-layer virtual switch is designed to enable massive network automation through programmatic extension, while offering continued support for standard management interfaces and protocols<sup>7</sup>.
- **OpenStack** - A collaboration of developers and cloud computing technologists, OpenStack open source software controls large pools of compute, storage, and networking resources via a dashboard and the OpenStack API, and also works with popular enterprise and open source technologies<sup>8</sup>.
- **Open Network Operating System (ONOS)** - A collaboratively developed SDN Operating System for service providers, that delivers the scalability, high availability, high performance, and abstractions service providers need to easily create new applications and services<sup>9</sup>. ONOS recently announced it has developed an open reference implementation for its Central Office Re-architected as Data Centre (CORD) concept<sup>10</sup>. CORD is a collaborative effort to bring cloud, SDN and NFV to service provider networks. Its service provider partners include AT&T, China Unicom, NTT Communications, SK Telecom and Verizon.

## Central Office as a Data Centre

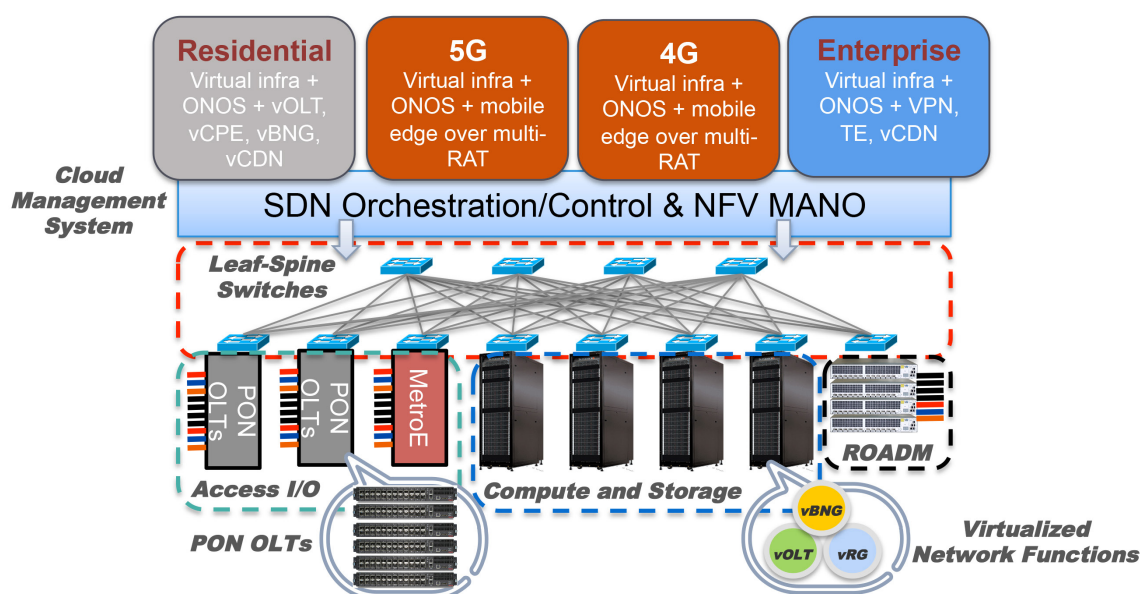


Figure 2 - CORD Framework

<sup>7</sup> Open vSwitch, "Production Quality, Multilayer Open Virtual Switch," <http://openvswitch.org/>

<sup>8</sup> OpenStack, "Open source software for creating private and public clouds", <https://www.openstack.org/>

<sup>9</sup> ONOS, "ONOS is building a better network", <http://onosproject.org/>

<sup>10</sup> Lightwave, "ONOS develops open CORD reference implementation", <http://www.lightwaveonline.com/articles/2016/03/onos-develops-open-cord-reference-implementation.html>

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The open networking ecosystem is being fostered by the efforts of several organisations, too. They include:

- **Open Daylight** - a collaborative open source project creating a framework to accelerate the adoption of SDN and create a solid foundation for NFV<sup>11</sup>.
- **Open Networking Foundation (ONF)** – a user-driven organisation dedicated to the promotion and adoption of SDN through open and collaborative standards development, which also introduced the OpenFlow standard<sup>12</sup>.
- **Open Compute Project** – a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure<sup>13</sup>.

The more SDN and NFV they have deployed and the more open their networks are, the less service providers need to depend on chassis-based hardware systems or worry about vendor lock-in issues, both of which stymie the evolution of profitable business models.

Open networks also support open, programmable APIs. Programmability enables multiple parties to collaborate with one another to speed up service velocity. Working together, third parties, vendors, and service providers with great ideas can design, develop, and deploy timely and profitable new apps for customers.

## Future - Programmable Networks

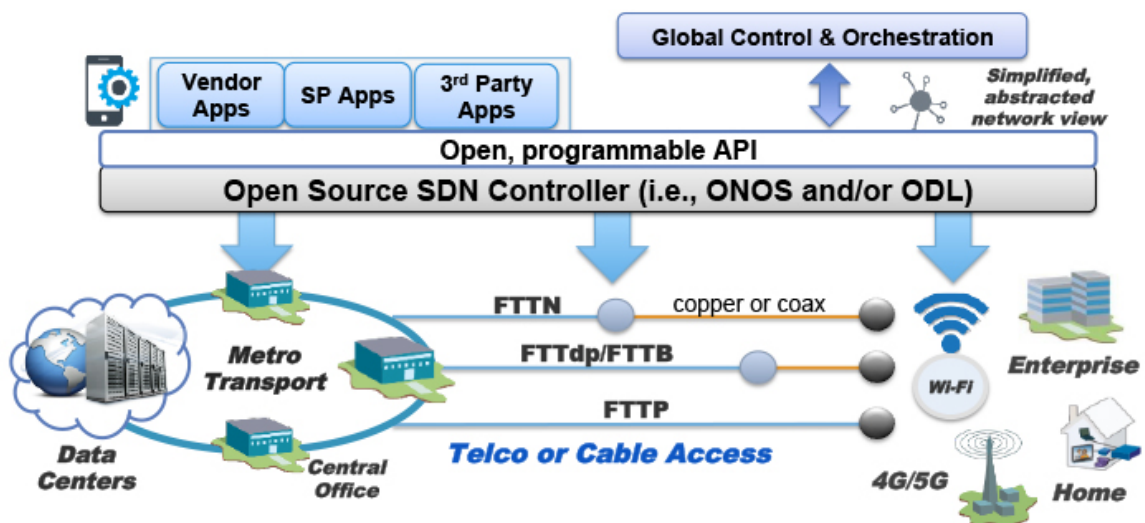


Figure 3 - Future Programmable Networks Framework

11 Wikipedia, "OpenDaylight Project," [https://en.wikipedia.org/wiki/OpenDaylight\\_Project](https://en.wikipedia.org/wiki/OpenDaylight_Project)

12 Open Networking Foundation, "ONF Overview," <https://www.opennetworking.org/about/onf-overview>

13 Open Compute Project, "About OCP," <http://www.opencompute.org/about/>



## Next-Generation Broadband Networks

Equipped with SDN and NFV, tomorrow's access networks will more closely resemble data centre networks than legacy networks thanks to the reduced OpEx, increased service levels, and unlocked networks the two technologies enable.

For example, SDN- and NFV-equipped Next-Generation Broadband Access Networks will incorporate features such as OpenFlow and service chaining, which will enable service providers to rapidly create and support new service models and support expanded service offerings through cloud peering capabilities. Both features will allow service providers to be very responsive to the changing market demand.

Future networks also will offer significant operational benefits to service providers. Those benefits include centralised policy management with virtualised residential gateways (vRG) and virtualised customer premises equipment (vCPE).

The implementation of network self-optimisation and real-time analytics will go a long way toward improving customer satisfaction and reducing expensive service calls and truck rolls. These innovations will enable future

networks to do a better job of proactively managing element resources through advanced troubleshooting. In addition to taking good care of customers, this will impact service providers' bottom lines positively. Time that used to be spent managing their networks and responding to trouble tickets will be spent on profitable efforts such as creating and selling new apps and services to customers.

Likewise, Next-Generation Broadband Networks' support of multi-domain, multi-vendor programmability enables service providers to truly embrace a best-of-breed, app-based approach which maximises the customer experience. Future networks' vendor neutral architectures will unlock single-vendor scenarios that have hindered service provider innovation for decades.

As their networks evolve, so will service providers and their business models. SDN and NFV provide a unique opportunity to serve their own interests and their customers' demands simultaneously. Only time will tell exactly how much service providers will be able to accomplish as their legacy networks reach new increasing degrees of SDN and NFV saturation. The sky may well be the limit.

## Sample Next-Gen Broadband

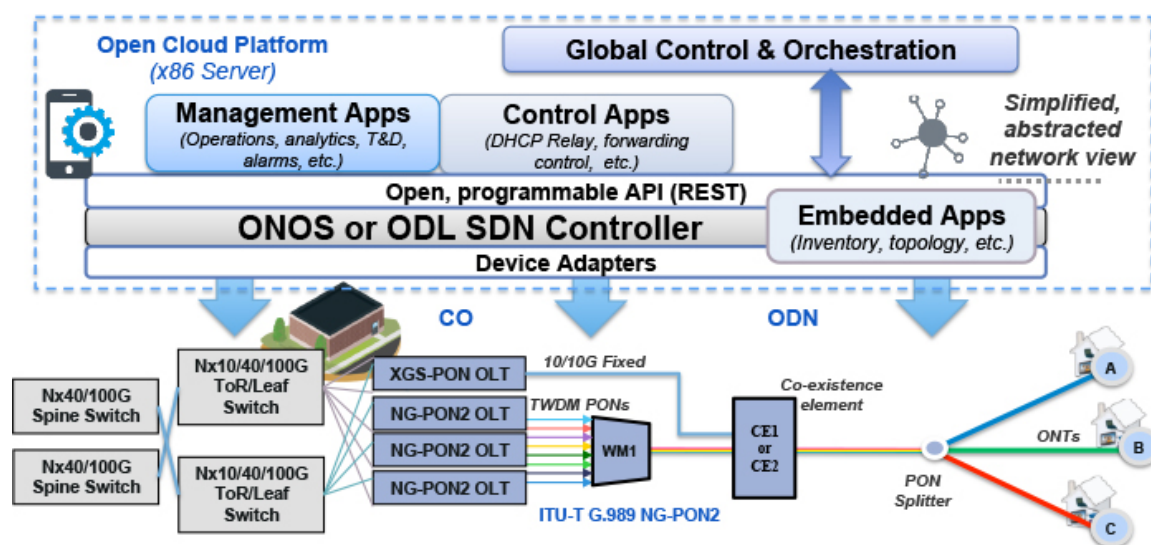


Figure 4 – Next-Generation Broadband Access Network

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