TNOVA

NETWORK FUNCTIONS AS-A-SERVICE
OVER VIRTUALISED INFRASTRUCTURES

GRANT AGREEMENT NO. 619520

Deliverable D8.12

Interim Market and Exploitation Planning and Recommendations

Editor Dora Christofi (PTL)

Contributors Georgios Dimosthenous (PTL), Felicia Lobillo, Aurora Ramos (ATOS), Marco Di Girolamo (HP), (ITALTEL), Thomas Pliakas (CLDST), Marius Negru (VIO)

Version 0.1

Date 22 December 2015

Distribution PUBLIC (PU)

Executive Summary

This is the interim report of the task T8.1. The main goal of D8.12 is to provide an update of the market areas and opportunities related to the T-NOVA platform and outlines common ground for the final version. The report identifies similar solutions to T-NOVA, the profitability of the NFV market along with the key forecasts. It defines how T-NOVA can be positioned in the relevant market, defines its target customers, the challenges and barriers it has to face within the relevant market while at the same time if defines and analyses T-NOVA's competitive advantages.

It defines the T-NOVA benefits, focusing on the marketplace, performs a SWOT analysis indicating the strengths, weaknesses, opportunities and threats of T-NOVA and defines a business canvas. Moreover it reports results from two NFV surveys

Finally this deliverable presents the project's expected results and reports a detailed and updated commercial exploitation plan with focus on the network operators and equipment manufacturers within the consortium also as academic exploitation plan by the T-NOVA consortium.

The final T-NOVA business plan that will be developed in the final year of the project under the specific task T8.1 will be reported in deliverable, D8.13.

Table of Contents

Table of Figures

1. INTRODUCTION

1.1. Motivation, objectives and scope

The Network Function Framework is the theoretical aspect of the T-NOVA system devoted to the definition of the structure and behaviour of the Virtual Network Functions (VNFs). It comprises a Network Function Store, where the VNFs are kept and made available to T-NOVA as building blocks for creating network services. Virtual Network Functions and network Services in T-NOVA are described, traded, and offered to users via the T-NOVA Marketplace. The Marketplace also opens the NFV market to software developers and traditional service providers to accelerate the adoption of NFV solutions.

The T-NOVA solution is expected to be an attractive revenue source for European network/telecom service providers, who are able to monetise their infrastructure by offering new services and by charging customers according to the actual usage of in-network resources, as opposed to claiming low, flat fees for plain connectivity services providing applications "over-the-top" with no QoS guarantees and no in-network treatment.

The T-NOVA Marketplace is one of the innovative concepts in the Network Function Virtualisation framework with the aim of promoting the VNF service offerings and facilitates the commercial activity and interaction among the different business stakeholders interact with the T-NOVA system.

The T-NOVA project will allow operators to deploy virtualised network functions, not only for their own needs, but also to offer these virtual functions to their customers, as value-added services. Virtual network appliances (gateways, proxies, firewalls, transcoders, analysers etc.) will be provided on-demand "as-a-Service", eliminating the need to acquire, install and maintain specialised hardware at customer premises.

The purpose of this deliverable is to make an assessment of the market areas and opportunities to be addressed by T-NOVA and to make an assessment of the existing market. The relevant solutions and services already in the target market are reviewed.

As outlined in other WPs, T-NOVA will contribute to helping expand market opportunities by attracting new entrants to the networking market.

Finally, a detailed commercial exploitation plan focusing on the network operators, IT service providers and equipment manufacturers within the consortium will be defined along with an academic exploitation plan by the T-NOVA consortium.

1.2. Document structure

Following this introductory section, the remaining parts of the document are structured as follows:

Section 2 presents and performs a market assessment for the Network Functions Virtualisation area by defining the NFV business goals, the related market profitability and presents some market forecasts which have been made by various market research companies. Further to that, it presents a number of T-NOVA's competitive solutions.

Section 3 presents T-NOVA's position in the related market, discusses the target customers and stakeholders, and defines the competitive advantage the platform has over its competitors. It then defines a SWOT analysis by identifying the strengths, weaknesses, opportunities and threats

and draws a business canvas for T-NOVA. Finally, the section presents the results of two NFV surveys which have been conducted by HP and the European Communications Magazine.

Section 4 presents T-NOVA's planned results, their impact, use and defines the exploitation strategy of the project by defining and updating each partner's individual exploitation plans along with the impact of their activities.

Section 5 finally concludes with the key results and presents future work that will take place over the final year of the project and will be presented in D8.13.

2. NFV MARKET ASSESSMENT

NFV involves implementing network functions in software that can run on a range of industry server hardware which can be relocated in various locations in the network as required without the need to install new equipment. It has promised to transform the entire telecoms infrastructure ecosystem by reducing CAPEX and OPEX. The following section makes an assessment of the current NFV market by defining the NFV business goals, investigating the market profitability, the NFV forecasts and finally describes a few NFV solutions.

2.1. Market Environment Study

2.1.1. Business Goals

NFV is expected to change the way telecommunication infrastructure is deployed and resulting in significant changes in the way services are delivered by service providers.

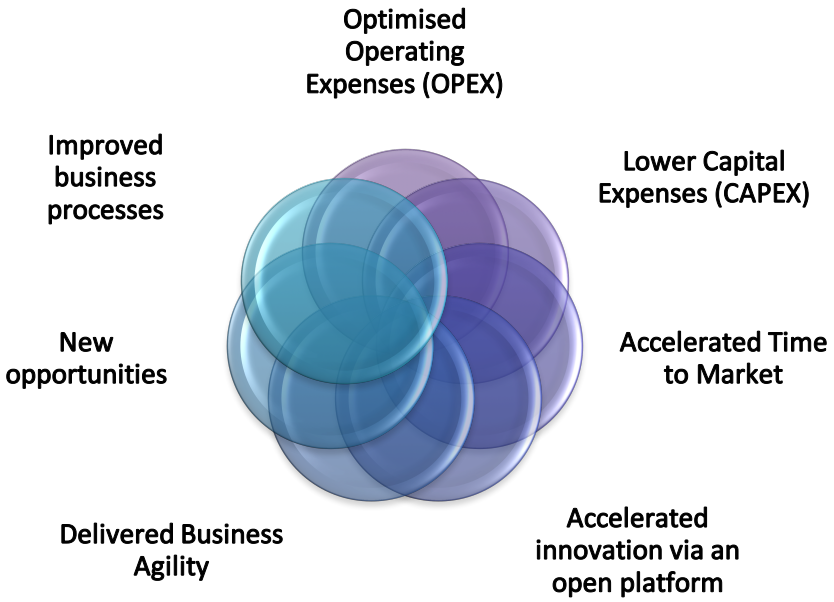


Figure 1: NFV Business Goals

The characteristics illustrated in Figure 1 will provide Communication Service Providers the opportunity to evolve in a more efficient mode of operations.

By reducing the unit costs of the infrastructure this will allow the Telecoms OPEX model to move to a **lower cost IT OPEX** model and reduce the cost for maintaining the infrastructure. Moving to the virtualisation model will **lower capital expenses** and will simplify the automation of operations. Deployment of new software and services can occur quickly and easily. With **remote and automated** deployment possible in order to address service needs. With an **open platform**, this will broaden access to partners such as network providers, start-ups, software vendors to innovate. NFV solutions provide **business agility** since it's easy to rapidly scale up or down applications, modify QoS and deliver new services faster. Service providers will be able to benefit from **new opportunities** to extend their portfolio with new virtualised services. It also helps in **improving business processes** since it facilitates decoupling between applications and the underline infrastructure, decreasing the challenges that service provides have to face [1].

2.1.2. Market Profitability

NFV is a core technology in the transformation of networks, particularly when paired with SDN. The virtualisation of networks is a key enhancement that offers a multitude of benefits to telecommunication operators by decoupling network functions from its historic pairing with proprietary hardware. These effects, in the business sense, are numerous; dramatically decreasing the CapEx and OpEx of the operator, as well as transforming the surrounding value chain with the larger implications of software-driven networks.

Network operator's recognise the disruptive aspects of NFV to their sector, especially given their close connection with the rise of virtualisation and cloud computing in the IT sector as a whole. A similar value proposition in CapEx, OpEx and business agility allows operators to ready themselves for new 5G business requirements while simultaneously restructuring their expenditure for the better.

According to Analysys Mason [2] telecom operators will slowly spend on NFV and SDN technology in the next 5 years (see Figure 2).

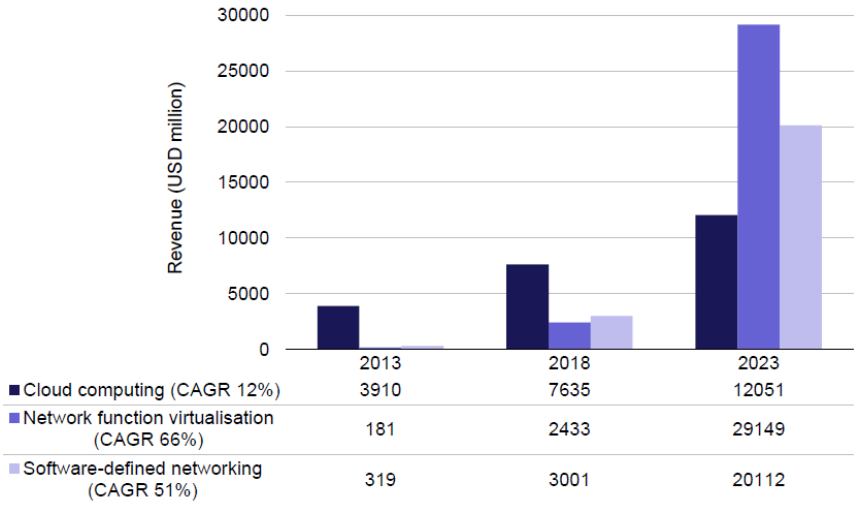


Figure 2: Analysys Mason forecasts exponential growth of NFV **[2]**

Gartner [3] sees a total combined NFV and SDN expenditure for network and service providers to reach $11.5 BN by 2017. The study estimates that more than 15 operators worldwide have already begun the transition. Analysys Mason [2] although estimating a more modest short-term forecast for 2017, foresees an exponential growth of NFV in 5 and 10 year forecasts, at 66% CAGR reaching almost $30 BN by 2023.

2.1.3. Market Forecasts

NFV promises to drive significant CAPEX and OPEX reductions and to transform the entire telecom infrastructure ecosystem. Mind Commerce [4] has estimated that the overall global market for NFV will grow at a CARG of 83.1% between 2015 and 2020. NFV revenues are expected to reach 8.7 billion by the end of 2020.

According to Infonetics [5] research, excerpts from the Carrier SDN and NFV Hardware and Software market size and forecast report, expect the SDN and NFV market to reach $11 billion by 2018.

According to the senior research director of carrier networks at IHS, the software is a larger investment than the service, storage and switch hardware, representing around 4 of every 5 dollars spent on NFV.

The value of NFV is in the virtualised network functions software rather than the orchestrator and control and makes up over 90% of the NFV software segment.

Infonetics Research [5] has distinguished the most important NFV Market Highlights. Service providers are still early in the long-term and forecasts 10-15 years of transformation to virtualised networks. Further to that the revenue from services which have been outsourced for NFV project is projected to grow at 71% with an annual growth rate between 2014 until 2019. Revenue from software-only video content delivery network (CDN) functions for distributing and managing data is forecasted to grow 30-fold from 2015 to 2019.

Another study published by FierceWireless [6] which was conducted in mid-2015 which reports that the global market for network functions virtualisation is expected to reach $11.6 billion in 2019, up from $2.3 billion in 2015.

2.2. Current NFV Solutions

This section provides a high level overview of the current NFV platform solutions delivered by some of the most important market players. NFV solution providers have frequent partnerships among themselves, leading to joint customer offerings. For example, HP has partnerships with Wind River and Alcatel-Lucent, although both have their own turnkey offerings, as described here below.

2.2.1. Helion (HP)

HP [7] has an integrated its NFV offering based on its OpenNFV reference architecture blueprint (see [D8.11], 5.1.6). OpenNFV is based on the ETSI model, extended with most of the components in the infrastructure layer (optimised for the NFV processing function)with intrinsic SDN support.

HP's NFV offering is made up by two main platform components:

- Helion (implementing the ETSI NFVI layer)
- NFV Director (implementing the ETSI Orchestration layer)

Helion OpenStack is HP's implementation of OpenStack, and offers all the functions requested to the VIM module in the ETSI architecture. HP is currently working with Wind River to deliver a specific Helion Carrier Grade flavour, exploiting the Wind River implementation of Linux and KVM. This Carrier Grade edition will provide superior availability and performance compared to IT-grade OpenStack, to optimally fit the tighter requirements of a NFV VIM module compared to a typical datacentre OpenStack implementation.

The Helion-based VIM supports different SDN control plane options, first and foremost OpenDaylight through the HP ConteXtream platform.

The NFV Director is compliant with the ETSI MANO specification. It is designed with an embedded core VNF Manager functionality, however it can also interact with external VNF Managers provided by VNF vendors. It supports both the ETSI interaction modes: either dealing with resource allocation, delegating the VIM interaction to VNF Managers (3-party Orchestrator-VNFM-VIM interaction – the mode adopted by T-NOVA), or directly communicating with the VIM on behalf of VNFMs (VIM proxy interface).

HP NFV Director has multi-PoP capabilities, being able to deploy VNFs and NSs across multiple sites. It is agnostic with regards to the VIM implementation, although in the HP offering it comes together with Helion OpenStack. It can provision VNF forwarding graphs on both SDN enabled and legacy networks.

HP NFV Director takes care of NFV platform monitoring, actively collecting measurements and providing a correlated view of all the physical and virtual resources making up the Network Service. It leverages acquired monitoring measurements (even integrated with information from external systems) to enact manual or automatic scaling and migration policies on VNFCs. It is agent-less (based on HP SiteScope), hence not requiring the installation of components on the monitored systems.

NFV Director's core component is a model-based coordination and control function, powered by HP Service Activator, implementing fully transactional workloads for service and VNF provisioning. Its service mapping engine employs advanced correlation techniques based on HP Unified Correlation Analyser (UCA) Event-Based Correlation.

Additionally, the HP NFV solution offers:

- Integration with HP OSS and IT Management tools;
- A VNF ecosystem, on-boarding VNF developers through a dedicated program (HP AllianceONE);
- A full portfolio of services, spanning from Consulting to Implementation, Management and Outsourcing of the NFV platform.

Figure 3 shows the full structure of HP NFV offering.

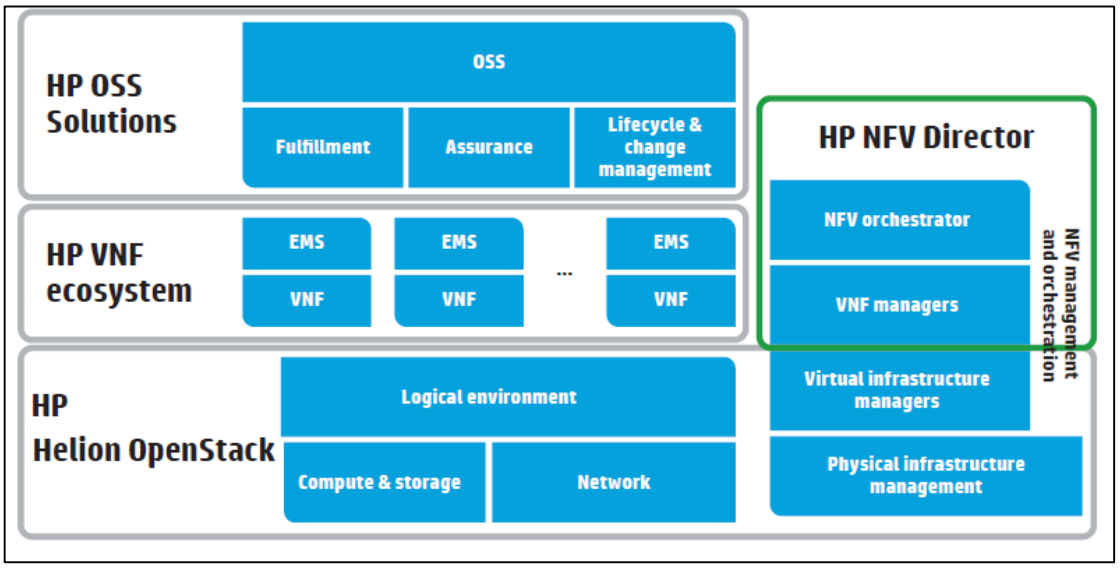


Figure 3: Structure of HP NFV offering

2.2.2. CloudBand (Alcatel Lucent)

CloudBand [8] is a NFV platform designed by Alcatel Lucent. This end-to-end solution ensures a high available service. CloudBand is based on Red Hat Enterprise Linux OpenStack platform for the provisioning of virtual resources management. The CloudBand solution is essentially composed by two

elements: the CloudBand Node and the CloudBand Management System.

The CloudBand Node is a software stack designed to manage hardware resources (compute, storage and network resources) for NFV deployments. Since the Node has been designed with the target of providing a High Availability (HA) service, it integrates monitoring functions. Moreover, both hardware and software upgrades can be performed without service interruptions.

The NFV Orchestrator function is performed by the CloudBand Management System that manages a set of cloud nodes. This module is also in charge of managing the application lifecycle.

CloudBand can integrate different SDN controllers, starting from Alcatel-Lucent's Nuage VSP (Virtualised Service Platform).

Alcatel-Lucent offering is completed by a set of VNFs, like VSR (Virtualised Service Router), vIMS, vEPC, vCDN. Alcatel-Lucent runs a dedicated program to on-board VNF vendors, named CloudBand Ecosystem Program, and has a complementary service offering for analysis, design, implementation and maintenance of CloudBand platforms.

2.2.2.1. Titanium Server (Wind River)

Wind River Titanium Server is a cloud software platform designed to address the demands of a carrier network. Wind River claims for Titanium Server a six-nine availability (99.9999%) that makes it suitable for carrier's needs. It is based on Wind River Linux and KVM editions.

Titanium Server extends OpenStack, adding reliability and availability extensions. VMs can be migrated in hundreds of milliseconds, and automatic VM failure detection and recovery mechanisms are implemented. Live VM migration uses DPDK, and protection groups logic is applied to increase resilience. This solution is fully open and compatible with most of industry standards.

This solution does not provide any NFV orchestrator, but users can choose which one to use.

Along with its technical platform, Wind River offers consulting, design and development services, through its Professional Services unit.

2.2.3. FusionSphere (Huawei)

FusionSphere [9] is a platform solution presented by Huawei. It is a cloud platform optimised for carrier grade applications. Red Hat Enterprise Linux OpenStack Platform is integrated into FusionSphere, so this is an open platform. This solution has two main components: Fusion Compute (that is the virtualisation engine) and FusionManager (the cloud management node).

FusionCompute is the module in charge of abstracting the underlying hardware, integrating server, network and storage resources into an elastic pool of resources.

FusionManager is the cloud orchestrator, enabling to manage virtualised resources in a unified way.

Figure 4 indicates the FusionSphere advantages [7]

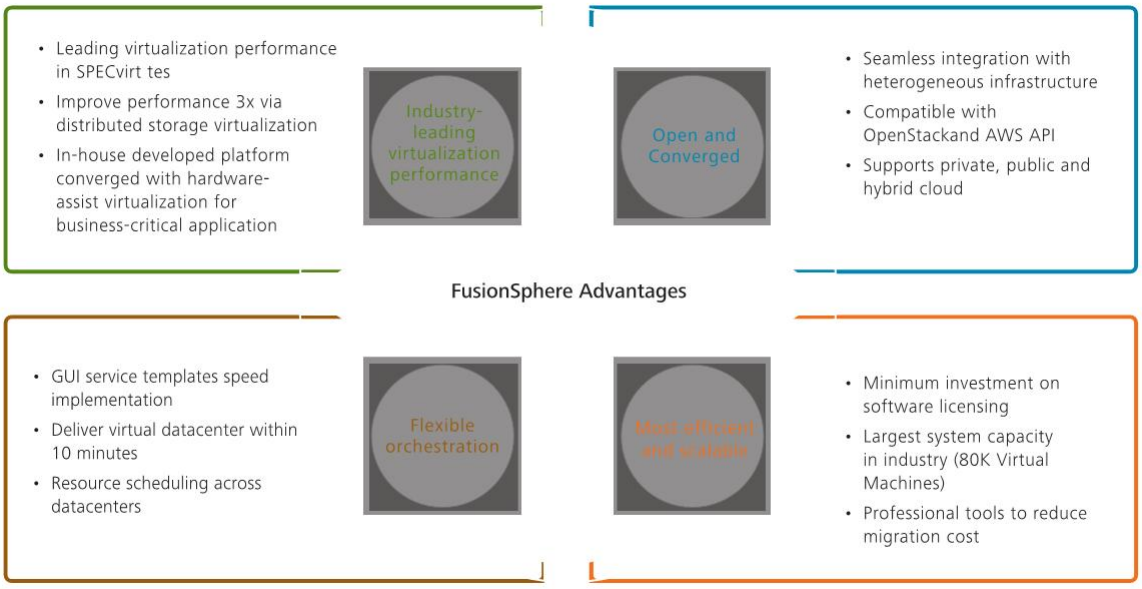


Figure 4: FusionSphere Advantages [7]

2.2.4. Evolved Service Platform (Cisco)

Evolved Service Platform (ESP) [10] is an end-to-end solution provided by Cisco. This cloud platform is able to create and provision services to deliver the desired outcomes for applications in real time using an open API, Software Defined Networking and Orchestration capabilities. Also ESP is based on OpenStack.

In particular, Cisco ESP architecture is composed by four essential modules:

- Service Broker: it is the storefront for the service providers, enabling operators to create and initiate a network function.
- Orchestrator Engine: this module connects the application to the infrastructure. The orchestrator links physical and virtual network functions, providing a unified framework. This allows operator to dynamically deliver customised services.
- Service Profiles: this module defines service attributes and policies in order to automate the delivery of personalised services.
- Catalogue of virtual functions: this is a set of virtual network applications. Linked to the service profiles, it creates the list of services available to customers.

The ESP solution can be shipped to service providers as individual function, as an integrated solution, or as-a-service model.

2.2.5. Juniper Networks: Contrail Cloud

Juniper Networks Contrail Cloud Solution [11] for NFV is a turnkey software suite that intelligently orchestrates and automates the provisioning, operations and management of a

wide range of VNFs and PNFs. This solution empowers service providers with agile service creation and programmable intelligence bundled with uncompromised carrier-grade scale and reliability.

Contrail Cloud is an open platform and ETSI NFV compatible to enable interoperability with standards-based solutions.

Uniqueness

- Contrail Cloud for NFV provides customers a solution to innovate and achieve their business objectives to lower cost of ownership and drive new value and services from the network.
- Juniper offers a platform that delivers scale, automation and agile service creation. Intelligence is provided through rich analytics and visibility empower the elasticity to scale up or out with on-demand resource provisioning.
- Contrail Cloud automation delivers full life cycle management to act on this data and create new instances based on business needs.
- Contrail Platform is designed with carrier grade scale, reliability and security to ensure the orchestration of an always-on and adaptable set of services.
- Service providers and Enterprises can create with the freedom of choice across all domains from cloud, edge, managed services, core and security.
- Contrail Cloud adopts an open standards based approach giving customers the freedom to choose the OSS/BSS components to manage full lifecycle of a service or application partners to create new value added services.

Scalability and Performance Characteristics:

Contrail Cloud Platform is responsive and adapts to resource provisioning levels on demand. This flexibility is reflected in three ways: elastically scales virtualised resources up and down on demand; scales infrastructure beyond data centre and cloud boundaries; and scales software out to meet required control and management demands

2.2.6. CENX - Lifecycle Service Orchestration Solutions for NFV and SDNs.

CENX's [12] Cortx product solution for Service Management and Assurance introduces a central management in order to eliminate operational complexity for next-generation network operations for NFV, and SDNs. The solution is built on open, vendor and network agnostic architecture and exploits a wide range of existing data sources (OSS and IT). Their solution provides features such as workflow orchestration (which reduces manual provisioning errors and the corresponding costs), capacity planning (enable service providers to buy or lease only needed resources) and continuous data audit. These features enable the network service providers to deliver new services faster, across physical and virtual network functions, and gain increased benefit from existing infrastructure.

Furthermore, it assures end-to-end performance across physical network functions and NFV efficiently with feature such as real-time troubleshooting, network analytics, and service level assurance (SLA) management capabilities. Real-time, contextual search combined with detailed macro-geographic and detailed path views enable operators to map data services and then drill down to individual circuit path segments with precision. It also leverages extensive analytics to

improve service quality and availability by comparing network related parameters such as frame/packet loss, latency, jitter and other performance metrics.

2.2.7. Nokia Telco Cloud Solution

Nokia's Telco Cloud [13] product solutions provide end-to-end solutions in order to enable mobile Telco operators to:

- Scaling mobile networks easily to meet unpredictable data traffic.
- Cost of ownership reduction by using standard platforms and deployment automation.
- Improved network experience by applying network analytics to predict traffic changes.

Especially, Liquid Core solution (part of Telco Cloud portfolio) makes the core network adaptable and flexible enough in order in order to meet rapidly changing data traffic needs and enable operators to deliver the best network experience to their customers. The main components of this solution include:

- Core Virtualisation - All core network functions can run on standard IT hardware in a virtualised manner and can be referred as NFV (based on ETSI NGV standarisation).
- Cloud Application manager - Automates many phases in a Telco's applications' lifecycle from development to deployment and maintenance. Furthermore provides automated elasticity management of cloud resources for efficient and flexible network capacity management.

3. T-NOVA IN THE MARKET

This chapter describes how T-NOVA could be positioned in the market emphasising the benefits it has to offer customers. Further to that it defines the target customers and stakeholders, the market barriers and challenges. Most importantly the chapter defines the benefits that T-NOVA has to offer and performs a SWOT analysis describing T-NOVA's strengths, weaknesses, opportunities and threats.

3.1. T-NOVA Market Position Plans

Product positioning is related to market segment and involves the creation of a unique consistent and recognised customer perception about a product's/service's offering and image. A product or a service may be positioned on the basis of a benefit, use or level of quality. In the case of T-NOVA, the service will be positioned based on the benefits it has to offer to its stakeholders.

Positioning T-NOVA involves creating a positioning concept which expresses the benefits of the service. Next, we need to come to an understanding of differentiating T-NOVA from its competitors *(see section 2.2).* These elements of positioning articulate how T-NOVA could serve its customers in a way its competitors can't.

The strategic triangle (as illustrated in Figure 5) is used to establish the competitive position of T-NOVA in relation to its customers and competitors. The framework is based on the premise that competitive advantage is determined by the ability to deliver greater value to customers at a lower cost than its competitors.

The first step before any market positioning is to identify the target customers which is the group of people or businesses that can benefit from T-NOVA. Along with having an understanding of their needs this will help to reach the target market via specific advertising which is positioned only for the T-NOVA target customer. The T-NOVA customers include the T-NOVA Customers, Service Providers, Network Operators, Function Providers and Function Developers.

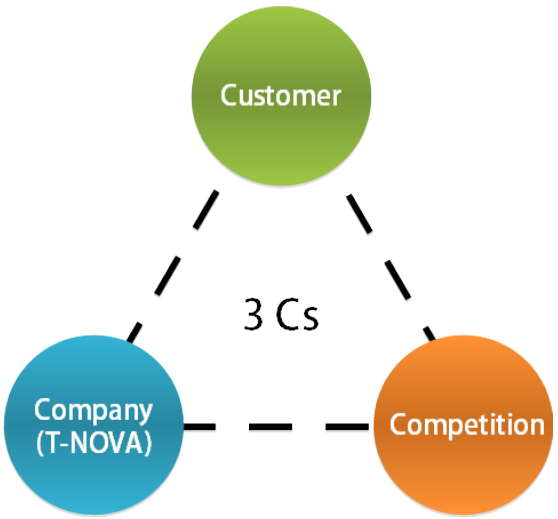


Figure 5: 3 Market Cs

The key feature of the marketplace is the ability to negotiate and acquire SLAs. Basically, the T-NOVA marketplace is the characteristic that positions T-NOVA within the relevant market and makes it unique from its competitors. T-NOVA, with the NFV marketplace focusing on NFaaS will allow network services and functions from various developers to be published and traded.

Customers will be able to browse the marketplace and select the services and virtual appliances that match their needs as well as negotiate the associated SLA and billing models. The customer will also have the ability to monitor and configure the offered services and functions.

3.2. Target Customers & Stakeholders

The target customers and stakeholders include the investors and parties which have an interest in the specific project. Figure 6 illustrates the customers and stakeholders who are involved in the T-NOVA value chain. The primary goal of T-NOVA from the viewpoint of its shareholders is to maximise profits and enhance shareholder value.

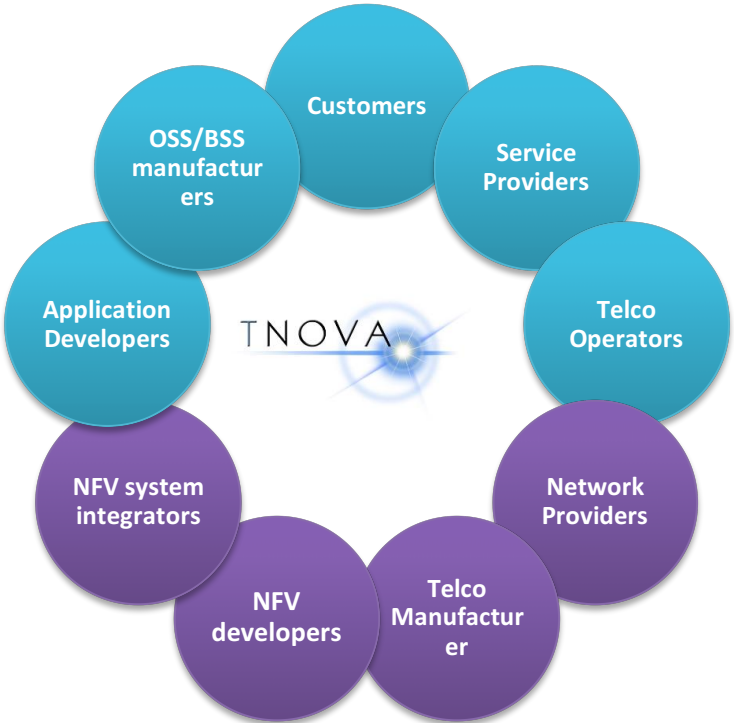


Figure 6: Customers & Stakeholders

T-NOVA Customers

The Customers purchase a service provided by the Service Provider in an as-a-service way and pay with a pay-per-use model. They select the service from a catalogue provided by the Service Provider, choosing features, performance, availability and all the quality parameters composing the Service Level Agreement (SLA) and are not interested in the actual implementation of the service.

The Customers benefit from T-NOVA NFV because they no more need to buy nor install dedicated hardware equipment for obtaining the services. In case the service was already provided by the network, a possible benefit will be the reduced cost, and the flexibility of use, especially in terms of elastic pay-per-use mode.

Service Providers /NFV System Integrators

Service Providers sell network services provided by a single VNF or by the integration of several VNFs. Therefore the Service Provider shall have the necessary systems integration skills in the NFV area. It creates its own service catalogue for its customers describing both functional and service level parameters and the associated price per use.

The Service Provider benefits from T-NOVA NFV for the reduction of capital expenses since the services are completely virtual within the network and execution environment of the Telco Operators. Moreover, they have more flexibility for creating services that are appealing for their customers because of the increased simplicity of integrating VNFs than hardware devices.

Telco Operators / Cloud Providers

Telco Operators own the cloud infrastructure for hosting, managing and operating network services based on the NFV paradigm. With the advent of NFV Telco Operators can evolve from traditional telecommunication service providers to a wider market addressing also other more sophisticated services. In wider terms we should consider that this business role could be played also by Cloud Providers. However, we have chosen to use the term Telco Operator just for the sake of simplicity.

Network Providers

Network Providers provide the physical connection to the cloud infrastructure. The role of the Network Providers is important in setting up and maintaining the requested quality and security related to a service for the duration of the service.

Telco Manufacturers

Telco Manufacturers are considered the main and most professional developers of VNFs. NFV provides Telco Manufacturers with the opportunity to renovate and extend their traditional product portfolio from carrier-grade equipment built on dedicated hardware to high-performance, high-quality network services in a virtualised environment.

Telco Manufacturers will benefit financially from T-NOVA's NFV thanks to the reduction of costs for the creation of new products due to the virtualisation of the network nodes. Moreover, they can maintain their competitive advantage from the ability to provide carrier-grade products even in a cloud environment.

VNF developers / Application Developers

VNF developers or application developers are considered a different actor than Telco Manufactures. VNF developers will benefit from T-NOVA NFV since they will have the possibility to enter a new market without the need of huge investments as it was required in the past.

OSS/BSS manufacturers

OSS/BSS manufacturers provide the set of products, resources, procedures for configuring, operating and billing the services provided in the network. The advent of the NFV brings evolution to their product offerings in order to cope with the evolution of infrastructure and services in cloud environments. The OSS/BSS layer is vital for a robust and efficient network and service operation.

OSS/BSS manufacturers will benefit from T-NOVA since they will be able to provide new product offerings and extent their activities due to the entrance of many new developers besides the traditional Telco manufacturers.

3.3. Market Barriers and Challenges

Market barriers, as indicated in **Error! Reference source not found.**, describe the barriers to entering a specific market.

As we have seen in section 2.2 a number of organisations with brand identification have already launched similar solutions through their long-standing advertising and customer base. This creates a barrier for T-TOVA to enter the related market and forces the new entrant to invest time and money to **differentiate** its product and overcome these loyalties.

When new entrants are required to invest large financial resources in order to compete in the industry, another barrier occurs. **Capital requirements** form a particular strong barrier when the capital is required for risky investments.

Switching costs include switching from one provide to another. For instance a customer might have a contract with another service provider and wishes to purchase a virtual function off T-NOVA which is provided by another provider. This will include some costs for the customers in order to break its contract/subscription and to use a T-NOVA VNF provided by another provider. High switching costs form an effective entry barrier by forcing T-NOVA as new entrant to provide potential customers with incentives in order to use T-NOVA NFVs.

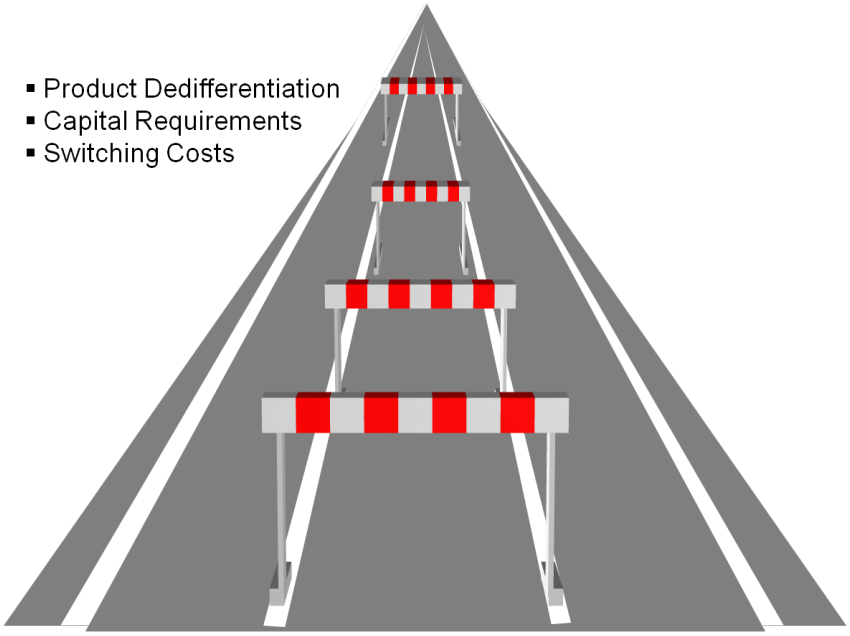


Figure 7: Market Barriers

Further to the market barriers which have been defined, there are some market barriers and challenges that T-NOVA is expected to have an impact on. T-NOVA has already contributed to SDOs and it's planning to continue contributing to SDOs and recommendation bodies impacting the standardisation challenges.

T-NOVA intends to provide management tools impacting the existing management tools challenges that other existing solutions might not offer.

Further to the above impacts, it's going to develop new business models impacting on the existing business model complexity. It's expected to impact the Telecom Operator value chain by allowing global and flexible network services that will be adapted and optimised based on the telecom operator's customers' needs e.g. provide better personalisation based on customer usage.

3.4. Competitive Advantage

The following section discusses T-NOVA's competitive advantage by providing greater advantages over its competitors. It specifically highlights T-NOVA's benefits offered to stakeholders including CAPEX & OPEX costs-related optimisation, agility and flexibility; reduce time-to-market. More specifically the section highlights the T-NOVA Marketplace advantage which is one of the innovative concepts in the Network Function Virtualisation framework with the aim of promoting the VNF service offerings and facilitates the commercial activity and interaction among the different business stakeholders interact with the T-NOVA system.

3.4.1. T-NOVA Benefits

The T-NOVA benefits offered to stakeholders can be sorted around 3 key market advantages:

3.4.1.1. CAPEX & OPEX costs-related Optimisation

Through the adoption of the T-NOVA platform, operators will be enabled to quickly and easily move and scale functionality to address changing needs and maximise the utility of the commodity hardware. Indeed, the provision of a variety of capabilities will be performed through the use of a single server, hence reducing the need to deploy, manage and maintain specialised hardware for specialised functions.

With the use of the T-NOVA cloud platform and then less equipment, organisations will be able to reduce the space, power and cooling costs associated with their deployments. Besides, common automation and operating procedures utilised by commodity hardware simplifies roll out and ongoing management.

Relying on the T-NOVA architecture, customers will not need to purchase or maintain expensive equipment spares; in the event of a failure, the shared virtualised infrastructure will simply move workloads to ensure ongoing capacity and performance.

The use of commodity servers will reduce hardware costs. Indeed, a wide variety of providers can offer these servers, increasing the volume and competition in the marketplace and, ultimately, driving down costs. Consequently, by upgrading the network every 2 to 3 years, instead of the traditional 5 to 7, an organisation can continue to effectively address the changing demands placed on their network and increase the value captured throughout the lifetime of those servers.

Also, by delivering the services in software, T-NOVA will be enable providers to rely on commercial of the shelve servers (COTS) to run network functions. This means the premium that a handful of vendors could charge for their proprietary hardware will no longer applicable or justifiable. Overall, virtualised functions developed by T-NOVA provide greater flexibility and less complexity in performance management.

3.4.1.2. Agility and Flexibility

Through the reduction of the amortisation cost of expensive equipment or the handling of “step-function” capital equipment acquisitions, network operators will be able to quickly and easily address customers’ demands. For instance, using the T-NOVA platform, they will provision a couple of servers to offer one-time use or short-term use services.

3.4.1.3. Reduced Time-to-Market

Thanks to easily installed and provisioned virtualised functions provided by the T-NOVA platform, will allow an operator to quickly deploy services when, and where they are needed, the time span required to market launch will ultimately decrease. Since a new service is simply implemented as a software module, and through the NFV commissioning of new services, operators are more flexible and will more easily tap into new market segments and thus revenue streams. From another standpoint, having to make any investment in hardware replacement or hardware expansion also means that lengthy procurement and installation processes can be omitted.

Furthermore, as the need for overheads, purchase and operation of the network elements decrease, including capacity expansions for more months or even years, operators and carriers

will be likely to increase their risk appetite towards new business models and adapt the T-NOVA platform and enter markets.

An additional asset is service innovation. The T-NOVA platform is supported by standardised frameworks e.g. Openstack, Opendaylight and Rundeck. This provides the ability to dynamically recover from failures, through the use of orchestrating framework, enabling operators and carriers to dramatically decrease the risk of deploying new products from vendors. Proof of Concepts (PoCs) in smaller scale environments and "fail fast" prototyping can be achieved, so providers can adjust and fine-tune their offerings to be confident with wider-scale deployments. Moreover, the ability to run virtual services on top of physical underlay networks means providers do not need to incur the time or costs of having to forklift upgrade their existing systems to add new services.

3.4.1.4. T-NOVA Marketplace

The T-NOVA Marketplace is one of the innovative concepts in the Network Function Virtualisation framework with the aim of promoting the VNF service offerings and facilitates the commercial activity and interaction among the different business stakeholders interact with the T-NOVA system.

As described in other deliverables; the customer will be able to browser and select VNF service offerings that meeting their requirements, negotiate SLAs, exchange their billing information with the service provide and keep track of the service they purchase.

The service provider will be able to acquire VNFs, interactive with different NF suppliers in order to compose network services as bundles of VNFs not only for their own needs but also to offer the composed Network Services to its customers. Network Function developers will be able to publish their VNF and trade them via the T-NOVA marketplace.

T-NOVA marketplace impact

- The T-NOVA marketplace will facilitate telecom operators to have greater choice and operational control of the network functions which they can deploy in their data centres.
- More rapid service innovation
- Reduce time to market for new services.
- Point of meeting between developers and telecom operators, increasing operational efficiency, facilitating the implementation of new services and accelerating the adoption of NFV technologies
- Contribute to the lack of tools in the market for efficient and reliable deployment and management of so developed services in a dynamic and scalable manner.
- Simplifies service deployment by offering service models for NFV
- Interaction between telecom operators and software developers (typically SMEs). Added value with respect other solutions for service composition/orchestration in which the operator did not have direct contact with FPs, moreover the T-NOVA platform itself tell the SP about the availability of deploying specific VNFs in T-NOVA.

The telecom sector and supporting stakeholders can greatly benefit from a platform to boost the adoption of NFV such as the T-NOVA Marketplace. T-NOVA enables the possibility of bringing

NFV closer to the market through "service" orientation (beyond lower level networking issues) and a NFaaS approach. The T-NOVA platform offers the concept of Virtual Functions-as-a-Service as an abstraction level and service provision model to facilitate the uptake of NFV. T-NOVA's target stakeholders are not only operators, but the larger value chain of the telecom sector, acknowledging the transformation that is taking place across in the telecom market with the introduction of software-driven networks. This transformation is creating new opportunities across the sector. Equipment manufacturers are already adapting their businesses to offer more software solutions in their network portfolio [14]. But the wider effect of a software-driven network is also the opportunity for other software-focused companies to enter the telecom segment, including SME developers, expanding beyond the historical operator/vendor relationship [15].

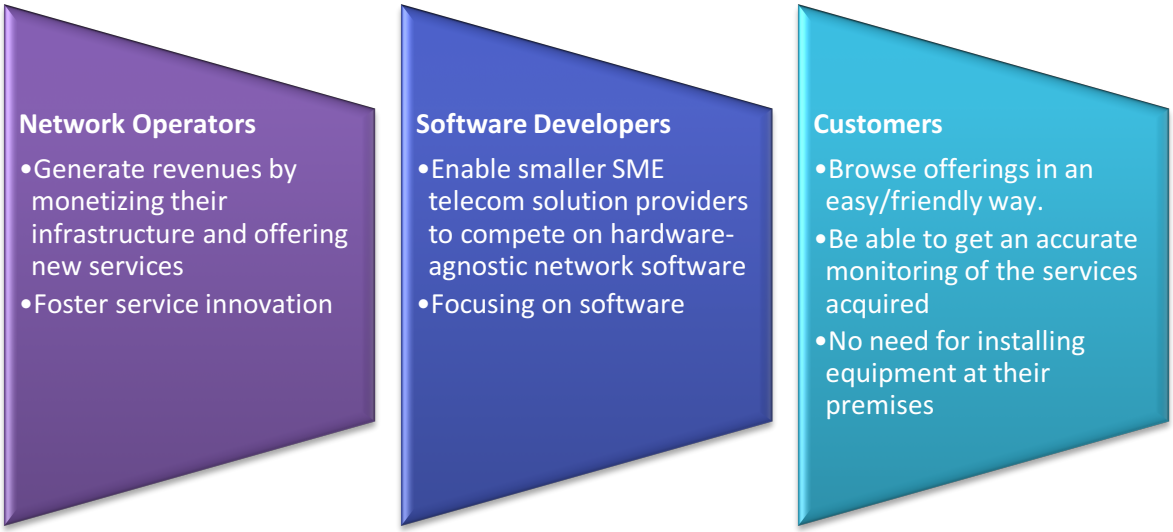


Figure 8: Marketplace benefits for stakeholders

Measurements

- # of PoC trials occurring at Operators and CSPs
- Infrastructure utilisation improvement
- # of functions and services implemented in NFV mode
- # of functions migrated from Physical to VNF

3.4.2. SWOT Analysis

SWOT stands for: **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats.

A SWOT analysis is used to guide you in the identification of your organisation's strengths and weaknesses (S-W), as well as broader opportunities and threats (O-T). Developing a fuller awareness of the situation helps with both strategic planning and decision-making in the future.

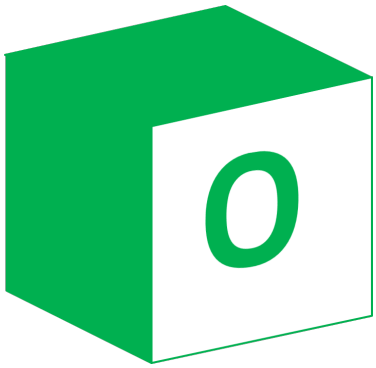
It's important to define the SWOT factors in order to help T-NOVA stakeholders and customers to identify if the project and its goals are worth pursuing and what it's required to make it successful. Figure 9 illustrates how the SWOT analysis will help the project partners and other stakeholders to compare the T-NOVA solution within its competitive environment.

Figure 9: T-NOVA SWOT

One of the main strengths of T-NOVA is the Marketplace which is seen as a business enabler. This is the innovative aspect which differentiates T-NOVA from its competitors and other NFV-

oriented initiatives. It's expected to bring OPEX and CAPEX savings. It offers the opportunity to users to browse a variety of provided network functions via the marketplace and select the one which suit their needs. T-NOVA allows the function providers to monitor of the acquired services. T-NOVA is supported by the European Commission since it's a project which has been co-funded financially. More importantly the partners who are involved in T-NOVA constitute a strong consortium.

T-NOVA is a project name which does not have high visibility at the moments it is only known within the research community; hence low brand recognition is one of the weaknesses of T-NOVA. The fact that T-NOVA is a research and development based project and not industrial is another weakness T-NOVA has to face. Also the TRL (Technology Readiness Level) which measures the extent to which T-NOVA is suited for deployment in a real operational environment is considered to be low since the project is still under development.



One of the main opportunities of T-NOVA is to develop a market growth strategy which involves entry into new markets. The T-NOVA partners and stakeholders will have the opportunity to foster new partnerships and relationships. Throughout T-NOVA, the partners are expecting to develop new business models that will benefit their organisation and further to that these will be applied to the rest of the actors and stakeholders. Network and Service Providers will have the opportunity to provide their subscribers with virtual services while developers will have the chance to provide their developed solutions via T-NOVA.

Competitive solutions with similar potential, functionality, features, efficiency etc. are the main threat for T-NOVA. The threat of new entrants refers to new competitors within the related industry. The existence of more competition means less profit for T-NOVA stakeholders. Also another threat includes the fact that T-NOVA is a 3 year research project and the support after the project's completion is uncertain.

3.5. Business Canvas Generation

In order to reduce risks and increase the likelihood of successful implementation, we propose to follow the Business Model Generation (BMG) process, an innovative and simple method developed by Alexander Osterwalder [16] and a community of researchers and business experts.

BMG offers a structured way to describe, plan, implement and execute the commercialisation of products and services. It is used by global enterprises, governmental organisations, SME's and start-ups for the planning and introduction of all kind of solutions and services into different markets. In order to make a business successful it is crucial to "understand the business drivers", the customer segments and value for potential customers, the channels for delivering value and more.

BMG builds on the Business Model Canvas (BMC) [16], a common and easily understandable framework for describing even complex businesses. BMC allows for the alignment of the different stakeholders involved, including management, R&D, marketing, sales and consulting.

The T-NOVA business canvas indicates the opportunities for the T-NOVA customers. It presents the relationship and partnerships between the T-NOVA stakeholders along with the potential revenues that will be generated. The customer segments involve the roles which have been identified and refined in previous deliverables [D2.2]. The value propositions indicate how T-NOVA will create value for its customer segments. The key activities include the most important things and actions that will make the business canvas to operate successfully. These are required to create and offer a value proposition, reach markets, maintain customer relationships and earn revenues.

3.5.1. T-NOVA Business Canvas

<table>
<tr>
<td>Customer Segments
T-NOVA Customers (C)
Service Providers (SP)
Network Operators (NO)
Function Providers (FP)
Function Developer (FD)</td>
<td rowspan="2">Value Propositions
Technological innovation
User Interface Simplicity
Incentives
Customer can obtain the best offers
Customer can participate in bargaining or auctioning processes
SP will offer various services
FP & FD will promote their functions via the marketplace</td>
<td rowspan="2">Revenue Streams
Pricing and procurement mechanisms
Licence, subscription, pay-as-you-go, pay-as-you-earn/revenue sharing.
Ongoing payments revenue
Advertising
• Infrastructure Monetisation (Operators)
  </td>
<td>Key Resources
Marketplace
Offering browsing
Customer Requirements
Function Availability
Service monitoring</td>
</tr>
<tr>
<td>Key Partners
Service Provider
Customer
Function Provider</td>
<td>Channels
Online accessibility
Functions accessible via the T-NOVA marketplace</td>
</tr>
<tr>
<td colspan="2">Customer Relationships
SP & FP: The service provider acquires VNFs from and the function providers.
C & SP: The customer (acquires network services provided by) service providers based on the combination of functions previously purchased.  </td>
<td colspan="2">Key Activities
T-NOVA Promotion
Continual development of platform
Continual development of services
Troubleshooting for customers
SLA establishment between the actors</td>
<td>Cost Structure
Marketing & Sales
Platform maintenance costs
OPEX
CAPEX</td>
</tr>
</table>

Figure 10: T-NOVA Business Canvas

3.6. NFV Surveys

3.6.1. HP 2015 – NFV survey

D8.11 reported the results of a NFV survey which was conducted in 2014. HP conducted another survey in January 2015 [17]. The survey reported a number of business key drivers which were addressed by the participating communication service providers for adopting NFV.

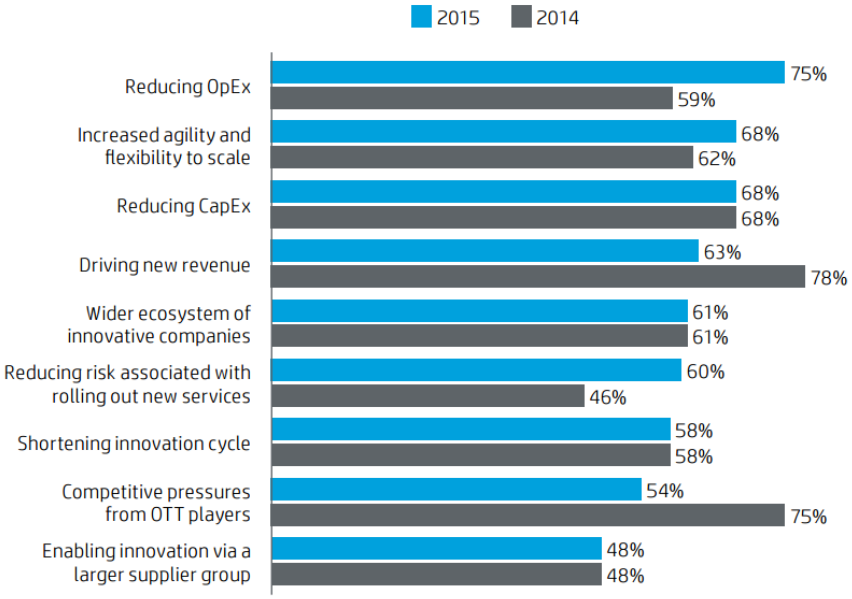


Figure 11: Business Key Drivers – 2014 & 2015 comparison [17]

The top business driver for network functions in 2015 is the reduction of the operational expenses (OPEX), which was selected by the 75% of the participants compared to the 2014 survey with a 59%.

The increased agility and flexibility to be able to scale up or down their services in order to address their customers changing demands is the second most important driver. New revenue is another driver however it's interesting to see that it has dropped to 63% compared to the 2014 survey which was selected by the 78% of the participants.

Figure 12 illustrates that the majority of the respondents (92%) in 2015 believe that NFV will make the underlying infrastructure more important compared to the 78% from last year's survey.

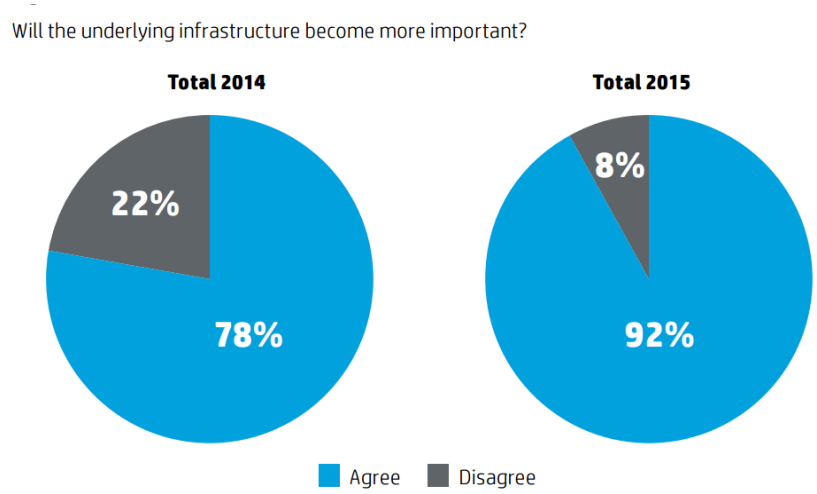


Figure 12: Infrastructure & Orchestration [17]

Figure 13 illustrates that there's also an increased in the importance of coherent orchestration across multiple NFV functions compared to 2014. The 92% of the respondents who agreed that the infrastructure will become more important also believed that scalable orchestration should be built into NFV planning.

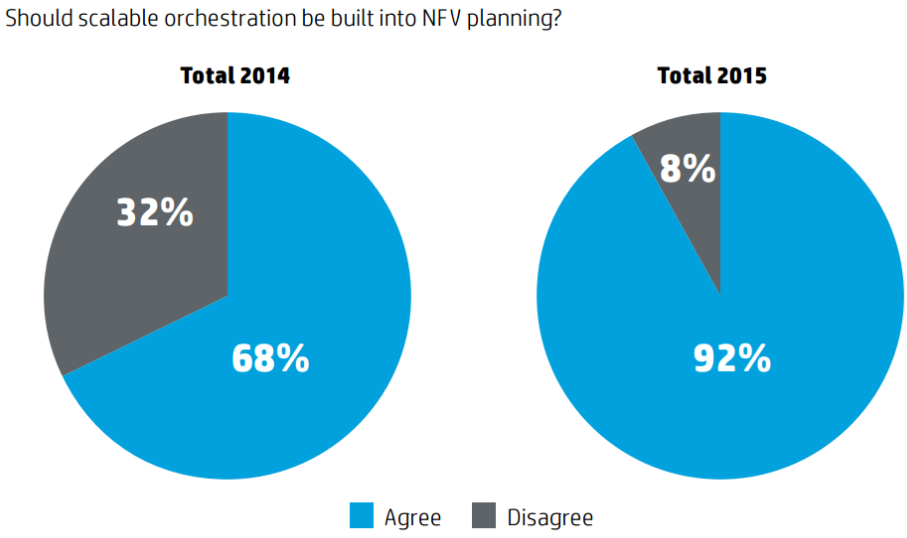


Figure 13: Infrastructure and orchestration [17]

Another important question which was asked during the survey, was regarding the evolution timeline of NFV. According to Figure 14 the majority of the respondents believe NFV will play a major role in the CSP market within the next 2-3 years.

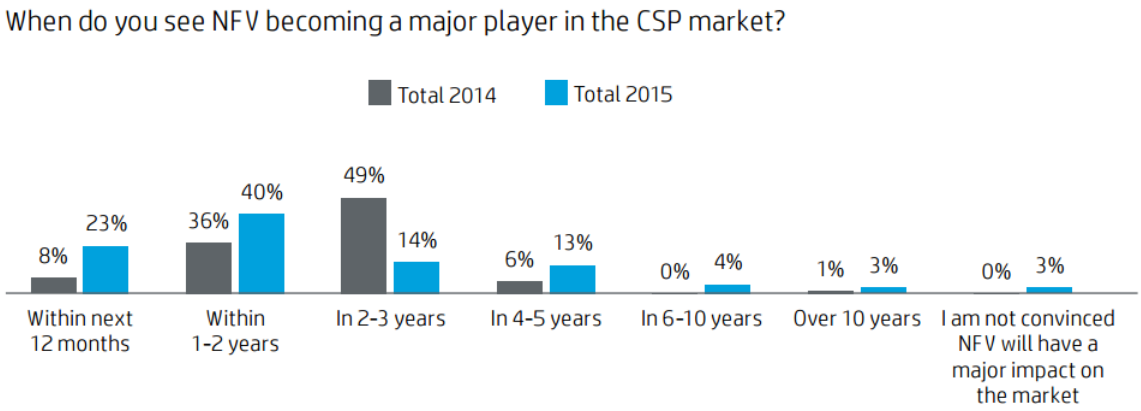


Figure 14: NFV role evolution [17]

It's also very interesting to see that according to Figure 15 the majority of the respondents expect to move from NFV proof of concept of trials within a timescale of 12 months to 2 years.

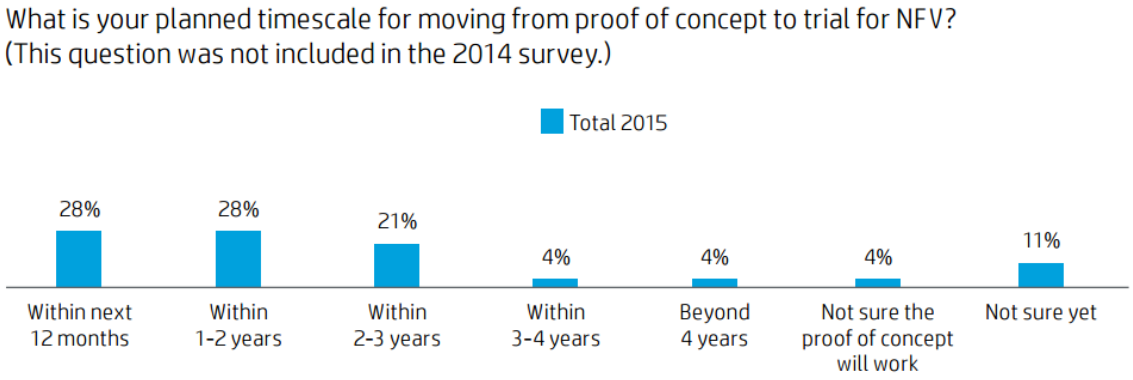


Figure 15: NFV Timescale [17]

It can be concluded from the 2015 HP survey, that

- NFV is a reality which is happening, and is igniting real preparations to adopt it within CSPs;
- Business drivers not substantially changed, but reinforced;
- Increased value perception of Orchestration, another indicator that a significant breadth of VNFs is expected to hit the market in the forthcoming years;
- Increased belief that opportunities can be realised by coupling NFV and SDN evolutions;
- Timeline is getting shorter, and 2017 is expected to be the year of trial "explosion".

3.6.2. European Communications Magazine

As far as challenges are concerned, according to the European Communications Magazine [18], who carried out a worldwide survey among one hundred telecom players (40% operators, 34% vendors, 26% third parties such as analysts, consultants and regulators) published in Q4 2014, the main challenge for adopting SDN/NFV is related to the integration with legacy infrastructure and technology (Figure 17). The second most important issue refers to the lack of skills and the large learning curve.

Another important challenge derives from the fact that 61% of respondents considered that the introduction of NFV/SDN might have a negative impact on the performance end users perceive (Figure 16).

Another relevant piece of information this survey reveals is related to the status of commercial deployment of NFV technologies. The vast majority of respondents have yet to implement the technology and expect roll out for after 2016 (Figure 18).

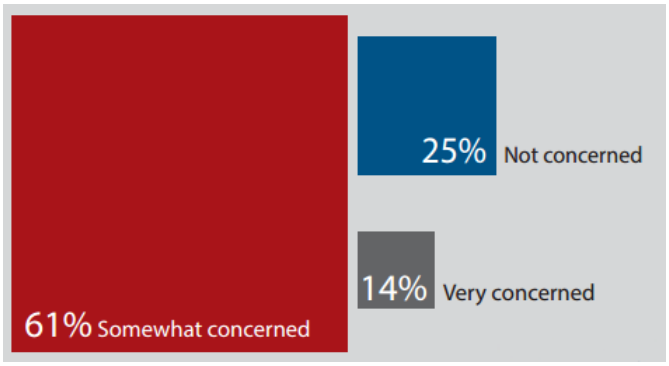


Figure 16: How concerned are you that introducing SDN/NFV will hinder the performance that you offer end users? [18]

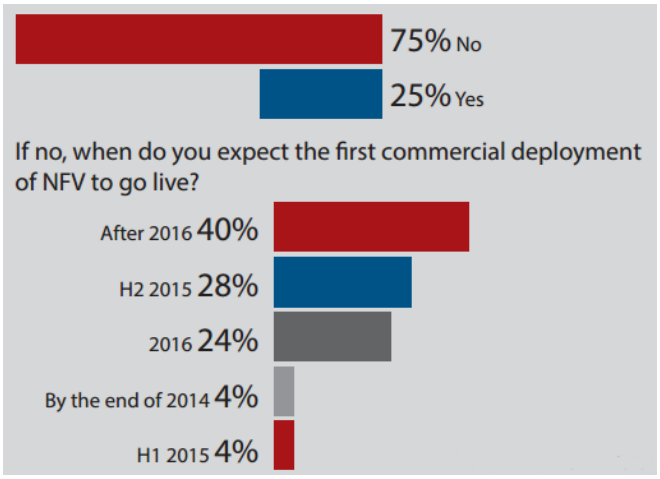
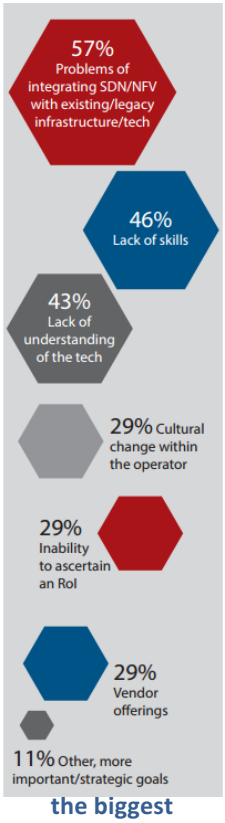


Figure 18: Have you commercially deployed NFV as part of your infrastructure? [18]



the biggest challenges to implementing SDN/NFV currently [18]

3.6.3. Survey Conclusions

As general conclusions, the surveys in the previous sections show:

- Challenges such as the coexistence of legacy technology and NFV do worry telecom players;
- The learning curve for NFV proficiency is suspected to be large;
- Cear evidence that NFV is a reality that is happening, and is igniting real preparation to adopt it within CSPs;
- Business drivers not substantially changed, but reinforced;
- Increased value perception of Orchestration, another indicator that a significant breadth of VNFs is expected to hit the market in the forthcoming years;
- Increased belief that opportunities can be realised by coupling the NFV and SDN evolutions;
- Timeline is getting shorter, and 2017 is expected to be the year of trial "explosion".

With respect to the challenges related to the learning curve and the lack of qualified staff, the T-NOVA platform includes a dashboard for all users (providers and customers) to making the use of NFV easier and more understandable, which of course fosters the uptake and facilitates the acquaintance of this technology.

As for the coexistence of legacy and NFV, there is still work to do in terms of studying the adoption path and the impact on legacy systems as NFV is deployed, including orchestration aspects in scenarios in which virtualised and non-virtualised elements have to cooperate.

4. T-NOVA EXPLOITATION

One of the key issues is to identify potential early adopters of the T-NOVA solution and steer the results *(see section 4.1)* towards a commercial exploitation strategy. This chapter defines the exploitation strategy per partners and the uptake of the T-NOVA results.

4.1. Planned Results

Figure 19 illustrates the results which are expected to be produced upon the completion of the T-NOVA project.

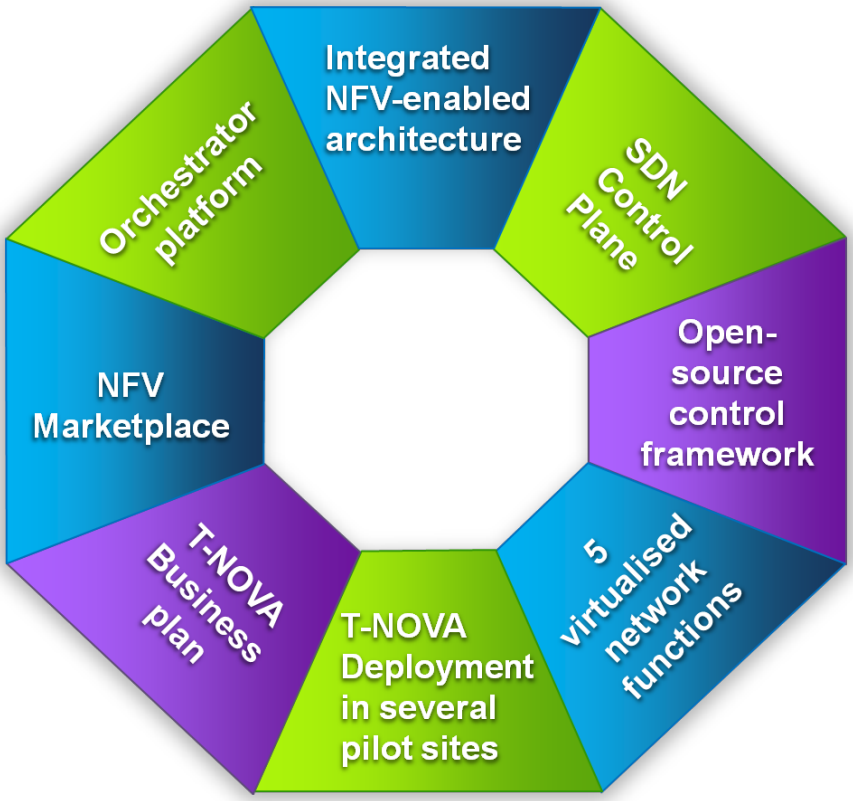


Figure 19: T-NOVA Planned Results

Integrated NFV-enabled architecture: The detailed design and specification of an integrated NFV-enabled architecture for the provision and maintenance of VNFs as-a-Service. The final T-NOVA architecture will be compatible with the ETSI ISG NFV guidelines and will harmonise with other ongoing efforts such as OPNFV.

Orchestrator platform: for federated management of Network and Cloud resources for VNF accommodation that will be open source software.

SDN Control Plane: A novel SDN control plane, leveraging the OpenFlow technology, for network management, slicing and QoS provisioning, accompanies by a universal Software Development Kit (SDK) for development of open source SND control applications. T-NOVA aims to produce a tailored SDN-based network management solution for NFV applications.

Open-source control framework for the VNFs configuration and monitoring: In line with the ETSI vision, T-NOVA will build a middleware that will allow VNFs by multiple vendors to interact with the T-NOVA architecture.

NFV Marketplace: A set of open tools for the NFV Marketplace which will include an open-source Function store. As outlined throughout the deliverable, the T-NOVA Marketplace can be seen as a business enabler which uniquely differentiates T-NOVA from its competitors and other NFV-oriented initiatives.

Five virtualised network functions: for the demonstration and assessment of the T-NOVA platform that will be used to demonstrate various business scenarios. The NFVs include the Virtual Appli cation Classifier, the Virtual Session Border Controller, the Virtual Security Appliance, the Virtual Home Gateway and the Virtual Proxy.

Deployment of T-NOVA in several pilot sites: This will test the platform against the defined use cases and validate the operation of the T-NOVA architecture.

T-NOVA Business plan: that will address the relevant actors, elaborating on the different market opportunities for each actor.

4.2. Impact of T-NOVA Exploitation

T-NOVA, with the use of cloud infrastructure to accommodate network functions, is expected to improve energy efficiency of access and transport infrastructures since all operations will be off-loaded to an IaaS cloud platform. Network Operators won't need to purchase expensive network equipment, allowing them to deploy new functions and protocols within their network.

By exploiting T-NOVA, network and service providers can monetise their infrastructure and offer new services by charging their customers based their usage. This will reinforce the role of providers and operators to gain business advantage since they will be able to provide their customers with specific services instantly.

T-NOVA's industrial partners and stakeholders will have the opportunity to exploit T-NOVA for specific use cases and to virtualise their platforms. By virtualising their platforms, this provides them the opportunity to develop new business models, provide new services and widen their target customer groups by strengthening their position in the relevant market they are operating in.

SMEs will have the opportunity to expose their assets through the T-NOVA Marketplace, with low costs of entry, exposing them to a wider audience. CAPEX will be transformed to OPEX by offloading network services to virtualised infrastructure. This will create unique opportunities for them since they will have the chance to enter new markets easier. This will have a huge impact on fostering SME involvement and innovation.

Academic partners aim to exploit the T-NOVA technical findings within their teaching materials. Academic courses will be enhanced by tutoring specific concepts related to SDN/NFV applications. Students will have the opportunity to obtain hands-on-experiences with network virtualisation and function development.

4.3. T-NOVA Exploitation Strategy

T-NOVA exploitation will be classified into individual partner and joint consortium exploitation:

- Individual exploitation involves the exploitation from the project consortium partners, in order to enhance their own activities and products and to provide better services to their

customers. This has the aim to provide a competitive advantage of the individual consortium partners and effectively contribute to the benefit of the targeted users.

- Joint consortium exploitation involves the exploitation activities of the project results, which are jointly carried out by the partners of the project. The T-NOVA test-bed is a specific example of such a framework: partners will jointly evaluate the proposed architecture and the components that will be developed in the context of the project.

The project beneficiaries will target to exploit different project outcomes depending on their specific interests. A distinction is made between the partners involved in T-NOVA, namely industrial partners as well as academic partners comprising research institutes and universities. This triggers an additional classification of exploitation in commercial and non-commercial exploitation.

The following section describes each partner's exploitation plans, giving emphasis on the industrial partners. The consortium has identified the impact of their exploitation activities and future plans T-NOVA might have within their business processes. The effective transfer and exploitation of the T-NOVA results, together with the improvement of existing practices produces positive impact for the stakeholders.

4.4. Industrial Exploitation

Industrial exploitation is mostly relevant to industrial partners and aims at transferring research results and outcome into new products and services. Therefore, T-NOVA's industrial partners (i.e., operators, manufacturer, and SME) are focusing their exploitation activities on improving their current operation and business position in existing markets, and on the creation of and preparation for new markets, with the intention to secure a strong leadership position in these new markets.

4.4.1. Network Operators

4.4.1.1. Portugal Telecom Inovação (PTIN)

Evaluation of the potential impact and exploitation of T-NOVA results by PTIN should take into account its dual role, both as provider of network systems and solutions, serving customers across a wide range of geographies, and as innovation centre of PT, the Portuguese leading network operator.

In relation to the first role, the results of T-NOVA provide a valuable contribution to prepare PTIN's transition to next-generation products and services, enabled by virtualisation and network programmability, with a significant impact on several areas of the current portfolio of products and services, including, among others:

OSS/BSS systems: T-NOVA provides the suitable environment for the conception and evaluation of novel OSS/BSS systems, able to cope with the dynamics of virtualised network functions and "on-demand" network services, incorporating NFV orchestration functionalities.

Network control systems (e.g. PCRF, ANDSF): the T-NOVA testbed infrastructure will be able to accommodate as VNFs virtualised versions of network systems offered by PTIN, for experimentation, evaluation and validation purposes.

Network monitoring systems: T-NOVA will permit to identify and evaluate the new requirements and challenges posed by virtualised network functions, on-demand service instantiation and increasing integration of IT and network infrastructure.

T-NOVA results will also enhance PTIN's network virtualisation and cloud networking testbed and provide a suitable experimental environment for upcoming R&D projects focused on 5G technologies.

From a PT perspective, T-NOVA will help to showcase and evaluate next-generation services to PT operational and business units based on the "on-demand" paradigm to deliver services to business and residential customers.

Last but not least, PTIN will make use of the experience and results obtained in T-NOVA to disseminate knowledge internally through technical workshops and publications.

Impact

SDN and NFV are already changing the landscape of network operators, but the process is generally considered to be a very early stage and the impact is likely to grow considerably in the future. The first NFV proofs of concept have been launched by most operators in cooperation with vendors and PT is no exception. Commercial launch of NFV services is expected to happen in the short/medium term, but the fully dynamic "as-a-service" model, advocated by T-NOVA, is likely to take some time. In this evolution process, experience and lessons learned from T-NOVA will provide valuable guidance about deployment, management and control of NFV infrastructure and services.

4.4.1.2. PrimeTel (PTL)

Network operators such as PrimeTel, are expected to generate attractive revenue by monetising their infrastructure, by offering new services and charging customers depending on their usage of in-network resources, charging flat fees for plain connectivity services.

New services will be planned, implemented and tested without the need of hardware. PrimeTel will be able to allocate in-network computing resources for function implementation and charge them according to usage. Each virtualised component will be able to run in its own protected resource space hence potential security breaches will not impact other functions that will run on the physical platforms. Finally, restarting and updating software for a given function can be performed without affecting other services and functions on the same platform.

PrimeTel is expected to generate revenue as a Service Provider by offering virtualised network functions as a service to its subscribers and charging them based on their usage.

Based on T-NOVA's outcomes the R&D department will frequently set internal meetings with the Network Department for presenting the proposed technologies and associated advantages for deployment as compared to existing methods and mechanisms used. The use of high-level knowhow, methodologies and tools developed in preceding research and industrial joint projects.

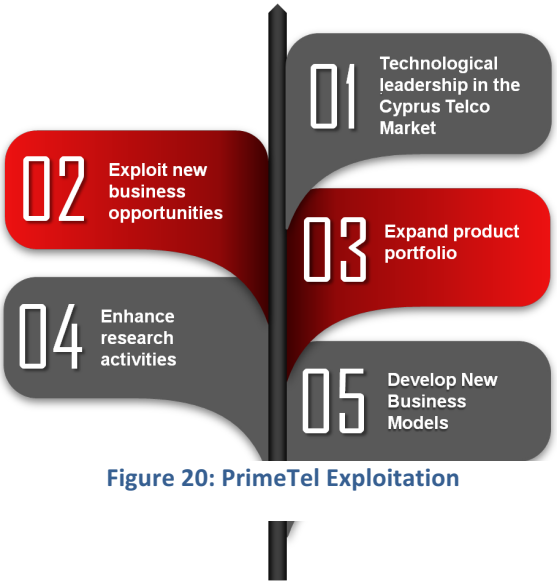


Figure 20: PrimeTel Exploitation

PrimeTel, as a network operator, will have the opportunity to avoid purchasing of expensive network equipment. This will enable the operator to deploy new innovative functions and protocols within their network with minimal delay and cost. This will impact the company and Network Operators in general since T-NOVA will improve the flexibility and economic, spectral and energy efficiency of access and transport infrastructures. It will dramatically reduce the costs of Service Providers and Network Operators by promoting energy efficiency since all operations will be off-loaded to an IaaS cloud platform.

PrimeTel as a service provider will provide the PXaaS VNF to its subscribers, both home and corporate users, as an added service. The PXaaS VNF will allow subscribers to use proxy services such as web access control, web caching, website filtering (parental control) and bandwidth control on demand. This will allow PrimeTel to expand its service portfolio and offer advanced services to its subscribers.

4.4.2. Manufacturers

4.4.2.1. Italtel SpA (ITALTEL)

Italtel's product portfolio covers mainly Service and Border/Gateway layer in TLC market, as briefly summarised in the following Figure 21.

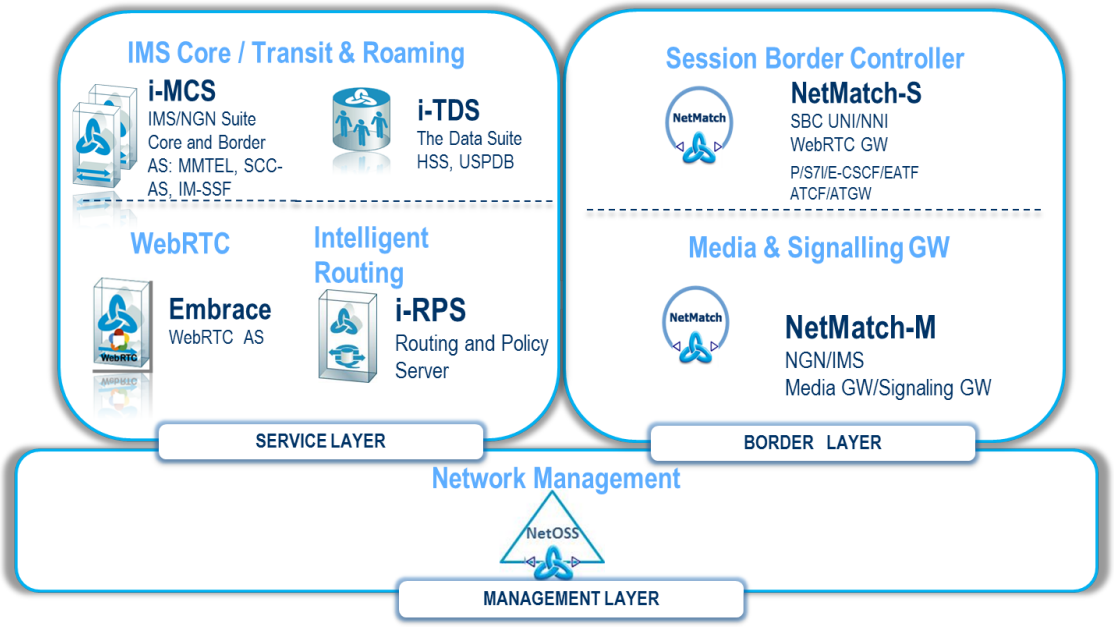


Figure 21: Italtel products

The products in the **service layer** are briefly described.

i-MCS (Italtel Multimedia Communication Suite) is an integrated solution for network convergence for both user and network services. It plays the role of enabler by providing signalling interfaces to all the kinds of networks (IP or TDM based, fixed or mobile) allowing the smooth network evolution towards innovative architectures.

i-RPS: Italtel Routing and Policy Server provides a centralised Routing and Policy Function (RPF) along with enhanced Service Control Capabilities. It takes the move from the great experienced achieved over the Next Generation Networks and in legacy PSTN/PLMN and, particularly, in the deployment of the i-SSW Italtel Softswitch. The product is applicable in all the network scenarios: pure IMS based or multi technology where PSTN/PLMN, NGN, Mobile R4 coexist. It addresses networks where the SS7 and SIP paradigms coexist and the operator has the need to harmonise the routing and policy functionalities among the existing and future environments.

i-TDS: provides a common database for user and service profiles in fixed and mobile IP networks. i-TDS adopts a layered approach that separates the application logic from the user data. i-TDS can be deployed as virtual appliance in commercial data centre using the best in class virtualisation software.

EMBRACE: it is a software-only and cloud-ready Web Application Server that could be used to enable WebRTC services in a TLC network or as a standalone WebRTC solution integrated in an ICT infrastructure

The **border layer** is covered by the NetMatch product family.

NetMatch-S: it is a multi-functional appliance for network and domain interconnection, enabling smooth “all IP” transformation. It is able to handle border control and signalling functions required in IMS networks at the NNI, as well as the User to Network (UNI) interface to support border control and signalling functions between User and Network planes.

NetMatch-M: it is a media and signalling gateway allowing the interconnection between the TDM circuit switched and the IP packet networks.

The **management layer** completes the TLC network solution.

i-NEM: Italtel Neutral Element Manager is a monitoring, diagnostic and configuration system that provides real-time resource-level management, encompassing Fault and Performance, Accounting, Inventory and Provisioning, Subscriber Management, for Italtel's NGN, IMS, Data and Application Servers Product Suite, as well as a selected set of third party network elements included in the relevant Italtel solutions.

Italtel believes that the innovation of all its portfolio passes through three important lines of development: i) virtualisation and cloudification of all its product portfolio, using all the features present in a cloud to provide scalability, flexibility and the other cloud principles; ii) improvement of the programmability of the network, statically and dynamically, to reach a better QoS and QoE, optimise operational activity (configurations of new devices or nodes) and for runtime activities (guarantee specified Service Level Agreement); iii) introduction of accelerated platform to enhance performance, reduce power consumption and optimise physical space of the solutions.

The main impacts can be summarised in the following:

- **Hypervisor and Cloud Management**: Italtel wants to move its products (starting from NetMach-S) towards an open source solution based on OpenStack and KVM, in addition to the commercial ones that it already has. The adoption of OpenStack can extend the set of certified platforms hosting Italtel's products and can provide a more flexible licencing model to best fit customer expectations and budget.
- **Orchestration**: Italtel wants to evolve its products towards the cloud principles at the basis of the NFV approach. Moreover it wants to evaluate an open-source approach for this layer, in addition to the proprietary one already existing. This can help to maintain close relations with all open-source initiatives started in this period.
- **Element Management System**: Italtel considers important to evolve its i-NEM product towards NFV EMS component, as a first step towards a new OSS/BSS layer in the next future. This can impact also the management of cloud platforms together with virtualised network functions in an integrated manner.
- **Accelerators**: Italtel wants to be ready when the market request for optimised solutions will start to grow significantly. GPU platforms will be an important option with a good chance to success, based on high performance and low power consumption.

The T-NOVA project is highly valuable for Italtel for different reasons.

Operators are moving the main functions of their networks, both fix and mobile, from distributed and dedicated hardware devices towards centralised and virtualised environment according to Network Function Virtualisation principles. In addition, in the last year we have seen a growing interest for non-standard modules (i.e. accelerators based on GPU, DSP, FPGA, etc.). This interest is increasing together with the activities carried out in the standardisation bodies (e.g. ETSI), in which Italtel is directly involved, especially to apply cloud concepts in the telecommunication environment.

T-NOVA supports the **Products & Services Unit** to implement the NFV and SDN strategy in progress, in particular for the network interconnection, in the border layer. The benefits are in three different sectors:

- First, products' evolution towards NFV and cloud concepts and towards the **abstraction of the network layer (PaaS, NaaS, SaaS).**
- Second, improvement of the capability to design all networks, with relevant possibilities to differentiate our offer in the consultancy market with an innovative support on the leading edge ICT technologies, architectures and SW/HW components.
- Finally our partnerships (in particular with Cisco Systems) will take many benefits from the activities inside the project.

In term of exploitation activities, it's worth to mention:

- Develop a fully NFV compliant prototype of a virtualised SBC (vSBC) deployed in a cloud environment exploiting scaling features.
- Develop new video transcoding functionalities over accelerated platforms, especially based on GPU (vTU).
- Investigate an open-source cloud approach instead of the commercial one, adopted until now.
- Develop specific service mapping algorithms for dynamically best matching the service requests with the system available resources, considering also the presence of hardware accelerated components.
- Develop algorithms to scale-out and scale-in service resources needed by applications based on monitoring information coming from IaaS, in conformance with ETSI NFV approach (through the VNFM).
- Integrate with an orchestrator and VNF manager able to optimise provisioning, deploy and runtime management of specific applications.
- Test and evaluate performance, service mapping and service composition in near to field environments.

4.4.2.2. INTEL

As shown in our demo at the 2015 NetFutures event in Brussels one of the most significant areas of interest for Intel is large-scale Orchestration. As NFV and SDN drive growing interest in the adoption of a Cloud Computing model in the Telco domain it is becoming clear that certain areas such as enhanced platform awareness (EPA), workload affinity for platform features and approaches to resource description models will play a critical role in driving real world deployments. Research into these topics within the T-NOVA is mapping directly to Intel's internal research agenda. Specifically our activities in T-NOVA are providing valuable insights into:

- Resource Landscaping
- Workload Analytics
- Profiling and Modelling
- Feature Awareness

To ensure convergence of R&D efforts into technologies developed by the Business Units (BUs) within Intel we have aligned the efforts of our activities within T-NOVA with our research framework Apex Lake as shown in Figure xx. We will demonstrate exploitation of T-NOVA research learnings through Apex Lake demonstrations at public events such as NetFutures in 2016 and the publication of per-reviewed papers related to our internal research activates on Apex Lake [19]. These efforts are aligned with the strategy and vision of Software Defined Infrastructures of Intel.

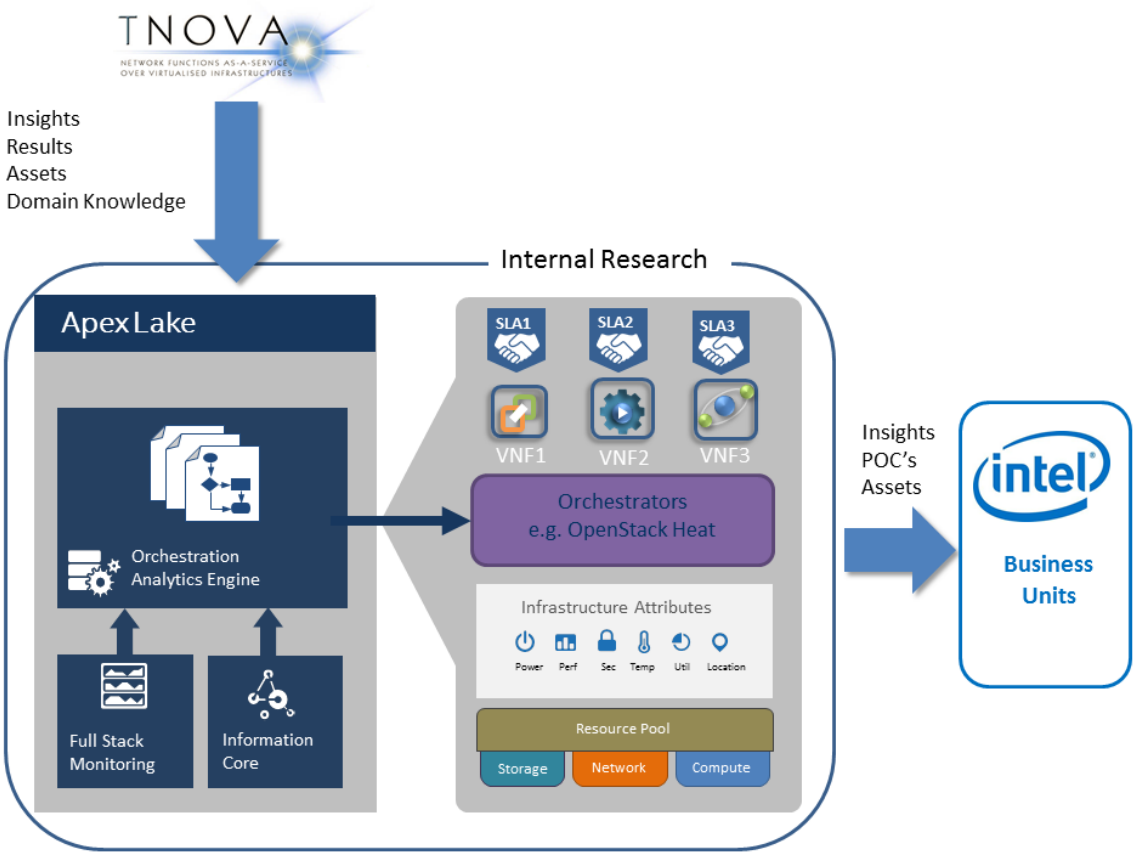


Figure 22: Exploitation of T-NOVA outputs into Intel's Apex Lake Research Platform

Intel's exploitation plan focuses around understand the telecoms ecosystem and exposing Intel's hardware and software platform ingredients through means of cloud computing. Intel believes that EPA in cloud computing environments such as OpenStack is critical to the successful adoption of NFV. Secondly the adoption of virtualisation enhancements such as SR-IOV, DPDK OVS-netdev, compute node CPU feature sets e.g. huge page support, specialised instructions e.g. AES-NI and careful platform optimisation e.g. BIOS settings etc. will play a critical role in delivering performant NFV deployments.

Impact

Combining the work on the development of an NFVI testbed and the VNFs being developed within T-NOVA is providing an opportunity for Intel to gain real world insights which can be shared within our internal business units. This also helps informs Intel research agenda and help to determine where disruptive innovation from Intel can help meet the needs of our customers and grow MSS. Secondly the research insights will be used to inform Intel's product groups (e.g. Data Centre Group) as to the capabilities and features required in the management of future 'intelligent' data centres. The T-NOVA project also provides Intel with an external proof point for Intel technologies and their successful application to support VNF workloads. Finally the assets being developed within the project such as the VNF Workload Characterisation Framework will be contributed to industry initiatives such as OPNFV in order to catalyse the adoption of NFV and SDN based on standard high volume x86 servers.

4.4.2.3. Hewlett-Packard IIC (HP)

Hewlett-Packard will have the opportunity to acquire extensive know-how on end-to-end NFV deployments and management lifecycles, with a

framework like the one developed by T-NOVA which is based on components of strategic business interest to HP, such as OpenStack and OpenDaylight. In addition, after the end of the project, some of the components developed by T-NOVA will be evaluated for a possible integration within HP's existing NFV solution portfolio.

Impact: T-NOVA will offer an outstanding amount of learnings, both on the technology side and on the business model side, which will be reused to increase the value of HP NFV service offering, with a particular attention to the know-how acquired about OpenStack and OpenDaylight usage within NFV environments. HP will benefit from such assets as a NFV systems integrator and concurrently vendor of cloud and SDN solutions. Furthermore, open components developed inside T-NOVA could be integrated into HP's NFV portfolio, to enhance it and/or offer a wider breath of solutions to HP NFV customers.

4.4.3. Technology Providers

4.4.3.1. ATOS Spain S.A. (ATOS)

Atos' portfolio around telecom will greatly benefit from T-NOVA results. NFV means virtualisation and software, something of which Atos has a lot to say about. The "softwarization" of the telecom sector with virtualisation and cloud technologies is very disruptive to today's telecom value chain, decoupling dependencies with underlying network hardware and focusing on software stacks.

In T-NOVA, Atos has the main interest of acquiring the expertise that will allow us to proactively evolve our Telco portfolio in order to be strategically positioned in an environment in which NFV is transforming the telecom landscape. This will be an opportunity for Atos not only to be prepared for new customer demands but also to enable new business opportunities thanks to the exploitation of the assets Atos has been involved in developing during the project (mainly the SLA management module and the T-NOVA marketplace).

SLA management system

Mobile Virtual Network Enabler (MVNE)

Atos is a recognised leader in Mobile Virtual Network enablement – accelerating time to market and empowering our telecom customers' global growth. Innovative new players compete side-by-side with established telecommunications companies – who in turn can turn the MVNO model to an advantage in both global and domestic markets

We deliver:

- Rapid time-to-market for MVNO and new service launch
- Massive scalability
- Focused service for niche players and Mobile Network Operators with international aspirations
- Our rugged, industrialised MVNE platform provides the foundation for any MVNO seeking to create immediate and differentiating value.

This solution can be enhanced with the adoption of the SLA management module. This module, initially conceived for cloud services, has been adapted in T-NOVA for a telecom-cloud environment and extended with telecom functions specific metrics, which are applicable to a MNO-MVNO business relationship with customer-provider roles.

As a standalone component for MVNO and MNO

The SLA management module can also be implemented as a standalone component for our Telco customers.

Currently, existing terms and conditions of MVNOs, do not usually offer QoS as such to their end-users. SLAs are more related to the coverage area and mainly state that the service provided depends on MNO service.

Moreover, SLAs offered by MNO do not encompass metrics beyond coverage, service interruption and very basic service delivery.

This enhanced automatic SLA offering is aligned with regulatory trends in the telecom landscape. The Connected Continent legislative package proposed by the Commission includes legislative changes that contemplate, among other aspects, new rights for consumers regarding the QoS. Operators will be required to supply (both public and contractual) information on the average speeds they actually provide to their customers during normal and peak times, data volume limitations, and on traffic management practices. Consumers can terminate their contract if there is a significant and non-temporary discrepancy between what they were promised and the service they actually get (e.g.: speed). All this implies the need for greater control of the service provided and consumed, to which the SLA management module can surely contribute.

T-NOVA marketplace

MyMarket is an innovative solution designed by Atos to facilitate Apps distribution and management within organisations. The solution is part of Atos HTTS (Hi-Tech Transactional Services) and fits within Atos leading Smart Mobility catalogue of solutions, together with solutions such as MyCity- smart solutions for city ecosystems - and Mobiret - mobile retailing solutions.

MyMarket helps organisations become more efficient during validation and deployment processes when offering a new set of apps to their users. MyMarket guarantees a secure server platform to centralise the publication, testing, final validation and distribution of internal and external apps. It also ensures that the apps reach the right people, according to access rights, among the organisations employees and external collaborator.

Some of the key features MyMarket offer:

- The business has an overall vision of its business apps and users, and can coordinate app publishing and distribution, can capture users' feedback in an easy way.
- Users get a tool to easily find their required and recommended apps, according to their profiles. They can access their company apps but also third party apps, even if they require a license fee. They are sure to obtain the latest versions, always updated, and can send feedback or report a problem.
- Apps are validated on quality, policies or security aspects before being launched.
- The service is available on the iOs and Android platforms, but it can also run on most market smartphones and tablet platforms.
- The platform enables the organisation to boost performance in all its business lines as it helps them to better mobilise processes. It can provide its employees and collaborators with the mobile solutions they require, in a secure and friendly environment.

MyMarket, initially conceived for mobile apps, can be evolved towards a T-NOVA-like marketplace, i.e., prepared to commercialise and distribute virtualised functions and be used by our customers for the deployment of NFV-based solutions along with Atos' services for system integration with billing or other BSS systems.

Adaptation of Atos' telecom portfolio for network virtualisation:

Atos needs to get its portfolio ready for the NFV paradigm. In this section we describe the pieces of our portfolio that we envisage will be boosted or will require evolutions in order to be adapted to virtualised networks.

• **Cloud offering**: Atos delivers a full-spectrum cloud strategy – from modelling and realisation to orchestrated performance of entire IaaS, PaaS and SaaS layers. We also deliver business process as a service, adapted for the telecom market and environment. We provide private, public, hybrid, community solutions or any combination of these. Whatever the technical organisation, we make it a business model fit for deployment across the complete enterprise.

ATOS expects to play an important role in the telecom arena as a Cloud Infrastructure Provider (CIP), hosting virtualised network functions. Although this is not the most relevant scenario in T-NOVA, where the cloud infrastructure is provided by the telecom operator itself, real scenarios will be more complex as far as business relationships are concerned. At the moment, we have cloud services for IT but we expect telecom services delivered in a cloud fashion as well.

• **BSS/OSS transformation solutions:**

- **BSS consolidation and harmonisation**: Atos harmonises telecom processes, helping our customers streamline their vendor landscape and consolidating their technology using a systematic methodology which removes cost, cuts time and limits project risk. This allows operators to drive new kinds of customer relationships based on service speed, flexible pricing and unique brand reach. Atos combines business process expertise with global integration skills, driving fresh value as the CRM, billing and other functionalities within BSS are transformed.

  With the adoption of NFV, this Atos' offering will be boosted since vendor lock-in will be eliminated and greater flexibility will be achieved. Atos will contemplate that some of the network functions will be virtualised and, at the same time, legacy solutions might remain, either temporarily as NFV advances or in the long run (critical functions might not be virtualised). All these aspects have to be taken into account in order to drive these changes along with our Telco customers. Atos can help operators rationalise their systems before adopting NFV, which is essential for a successful uptake.

- **Evolution Smarter Charging**: Atos Online Charging has been designed to improve CSP efficiency and enhance the customer experience. It sets new standards in price/performance thanks to its advanced real-time charging engine that can comfortably support the growing volume and complexity of services requiring real-time processing. In this way, Atos Online Charging helps CSPs move to a real-time data-centric business model based on convergent charging across all payment methods and service offerings. It is completely configurable to meet today's requirements while offering the flexibility and scalability to cope with rapidly-growing data volumes and evolving needs. The Atos solution is offered in conjunction with Matrixx, an Atos partner and a leader in next generation charging technology. The Matrixx Charging Engine is 3GPP-compliant for both online and offline charging, and complies with Diameter DCCA standards for event and session based rating. Radical changes to the underlying database and transaction management technology ensure no degradation of performance even for the most complex services, making Matrixx Charging Engine an LTE ready platform.

This solution can be enhanced with the accounting system especially designed for an NFV environment that has been developed in T-NOVA. The accounting system is notified about any status change of each Network Service (NS) or VNF instances for billing purposes. It is also interfaced with the SLA management module since the SLA result may modify the final price for the customer. This accounting system for NFV can be added to the online charging system by Atos in order to perform charging of NFV-related services. This also implies the integration of other OSS (legacy) and BSS (e.g. payments, dunning) systems, which Atos of course also covers as a service.

- **Mediation Solutions**: Atos Mediation is a next-generation mediation solution offering unbeatable price-performance and flexibility. It acts as a universal platform capable of consolidating legacy systems and transparently linking all systems and networks belonging to our Telco customer.
- By having only a single layer for collection and distribution of all BSS and OSS data, CSPs get a significant reduction in integration costs when compared to traditional vertical integration approaches.
- As well as reducing the costs and headaches associated with legacy systems, Atos Mediation has been designed as a future-proof platform that encourages service innovation and ensures CSPs gain a competitive edge when embracing new business models and revenue streams of the future.

  To solve these business challenges, Atos has teamed up with Digital Route, a leader in mediation technology. Atos Mediation is a next-generation mediation platform that supports all types of data exchange between any systems, so simplifying network architectures and supporting both online and offline transactions.

  Within an NFV scenario, this mediation system needs to be integrated to communicate with the T-NOVA orchestrator in order to receive the billable inputs from the virtualised network segment. In real scenarios, instead of using the T-NOVA billing system, the MNO will normally rely as much as possible on its legacy BSS and will produce a convergent bill including virtualised and non-virtualised services. However, of course, Atos always looks for the solution that best matches the MNO and the final layout will be made according to our customer requirements and following our harmonisation and consolidation of BSS systems perspective.

ATOS' Telco Network Products (Next Generation Intelligent Networks):

Telco Network Products (TNP) includes innovative, turnkey, carrier-grade, and cost-effective products that help Communications Service Providers (CSPs) deploy new services to generate more business value from their networks. Our TNP enable CSPs to achieve high-performance and flexibility when evolving their networks towards the all-IP paradigm. Our products have modular design and layered software approach and include: Virtual PBX, Mobile VPN, PBX Trunking, Core Network, IN Evolution, Prepaid IN, Messaging Centre, Number Translation Service, Wi-Fi Calling, VoLTE TAS and Roaming Applications.

These solutions provide high capacity and scalability to grow from small to very large deployments supporting tens of millions of subscribers, and tens of thousands of transactions per second.

All products are ready for immediate adoption either standalone or packaged together to enable CSPs launching disruptive offerings to different market segments, at the same time.

Figure 23: Overview of TNP offering portfolio by ATOS

TNP	Description
Virtual PBX	For Communications Service Providers (CSPs) looking to offer rich PBX-like functionalities to their customers independently of the customers' handsets, and without the limitations of having premise-based equipment
PBX Trunking	Allows CSPs to connect the existing enterprise premised-based PBXs into the CSP's network and deliver an extensive suite of communication and collaboration services with advanced quality and reliability, across multiple devices: mobile phones, desktop devices and integrated soft clients.
IN Evolution	The open, standards-based IN Evolution product from Atos addresses the key challenges CSPs face in transitioning their IN networks to an all-IP environment while preserving existing services. Controlled and flexible approach to migrate existing IN services towards an all-IP environment supporting both IP Multimedia Subsystem (IMS), LTE, and legacy SS7 networks.
Messaging Centre	The Messaging Centre from Atos allows CSPs to flexibly replace or offload their legacy end-of-life SMSCs with a low-cost and highly-reliable product that can be rapidly deployed, without any disruption to the business.
Number Translation Service (NTS)	With NTS from Atos, CSPs have a great opportunity to help businesses implementing new and efficient ways to attract customers with universal, free-phone, premium numbers… Atos has built the open, standards-based, and future-proofed NTS product to help CSPs address the flaws in number translation services of older proprietary technologies.
VoLTE TAS	The Atos VoLTE solution provides a robust and ready means to manage voice services across both LTE and 3G devices and networks.
WiFi Calling	Calling over WIFI service is defined as a voice over IP service with call originating, terminating, SMS MO/MT, MMS MO/MT, • USSD, star codes and all supplementary services. • The overall service follows IR.92 and associated 3GPP and IETF standards

This product suite by Atos will evolve with the uptake of NFV. All these components are interfaced with the operator's network through direct standard interfaces or gateways. For example, the VoLTE solution propagates service configuration across circuit switched and package switch network segments (e.g. call forwarding). As network elements are virtualised, these products need to be integrated into a new network architecture and ensure that virtualisation and additional management does not introduce any kind of service degradation in terms of latency, jitter, etc.

4.4.4. SMEs

4.4.4.1. Space Hellas S.A. (SPH)

SPH intends to leverage the NFV monitoring solution developed in T-NOVA in order to offer it as added-value service in its current cloud offerings - and, in the future, in its NFV services. This monitoring solution is not constrained to NFV, but can be also used for IT service monitoring, thus expanding and reinforcing the company's existing ".pulse" suite for IT intelligence.

Furthermore, SPH aims to leverage T-NOVA know-how in order to enhance its network as well as cloud offerings with value-added NFV services. SPH currently offers a hybrid cloud solution based on Microsoft Azure and British Telecom BT Express connectivity. This bundle is primarily focused on IT cloud services, yet with NFV enhancements it is expected to address a much wider range of customer requirements. Especially security-oriented VNFs will be valuable to secure the interconnection between the customer's private and public cloud segments.

Impact: The T-NOVA NFV solution is expected to boost the competitiveness of SME cloud and telecom service providers (such as SPH) and enable them to offer rich service bundles, combining traditional cloud/telecom resource offerings with added-value NFV functionalities.

4.4.4.2. Viotech Communications SARL (VIO)

VIOTECH conceives and markets high added-value innovative multimedia solutions offering unique terminal-free and context-adapted User Experience. Numerously awarded, their solutions blend people's entertainment and privacy expectations with providers' next generation services within the booming yet heterogeneous Digital Home Market, as figure 24 shows.

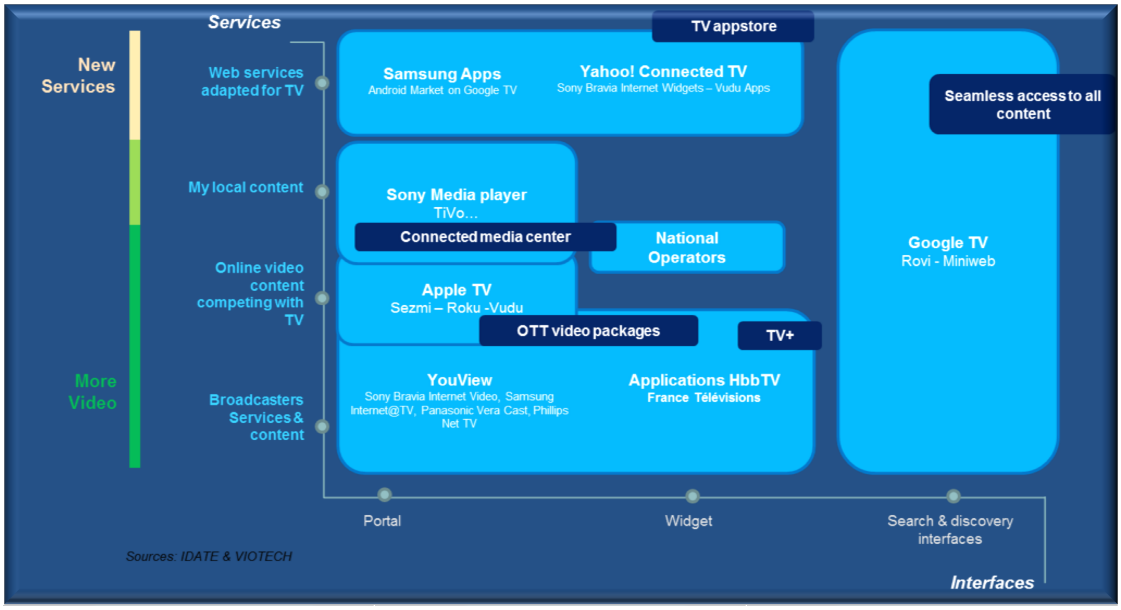


Figure 24: My eHome

Yet, as cloud-based services influence customer expectations for service personalisation and novel consumption pricing models, network operators need greater agility to innovate and respond to market opportunities. Market dynamics require shorter life cycles for technologies, applications and services; and network operators need to capture new revenue streams to compete profitably.

Network operators are key VIOTECH customers. Relying on the T-NOVA platform, VIOTECH aims to provide a comprehensive NFV solution to them through the integration of the virtual Home Gateway as the central device of their main offer ***My eHome***®.

The ***My eHome***® product range, marketed by VIOTECH, allows end-users to access, via a personalised interface, all familiar acquired & downloaded audio-visual content, stored in a central Home Gateway located in their home and accessible on different terminals (PCs, TV sets, laptops, PDAs, etc.). ***My eHome***® is commercialised both through Triple-Play or genuine operators as well as hardware manufacturers. Through the introduction of the vHG developed within the T-NOVA platform, VIOTECH will propose an upgraded offer in the cloud, including orchestration and automation, a deepened virtual network function catalogue and cross-domain capabilities. By doing so, for the present and future VIOTECH business partners (operators as well as content-related and/or service-related IT/Telecom actors, including SMEs), the NFV-driven added value is multiple:

- Optimised content delivery, service management, service composition;
- Hardware-related costs optimisation: With the use of a customised vHG, and thus delivering the gateway-related services in software, there is no need for high computation power and resources within the home equipment;
- More flexible and quickly adjustable creation of new services/applications (P2P);
- New business models and revenue sources;
- CAPEX/OPEX reduction for (1) innovative service deployments and (2) maintenance of equipment.

Practically, VIOTECH has identified and started, through the dissemination activities launched as early as 2013 (participation in CES'13, CeBIT 2013, CES'14, CeBIT 2014 demos to major Digital Home key actors such as Belgian broadcaster RTBF, European HDTV services providers for hotels

HOISTLOCATEL and QUADRIGA, African multimedia equipment manufacturing leader LIMITLESS, etc.), to initiate prospective commercial actions towards 6 targeted sectors:

- Digital Home Market towards:
  - **Content providers** (RTBF) looking to revenues & network investment optimisation through CDN avoidance, modular architecture integration, optimised R&D multimedia budget;
  - **Multimedia Equipment Manufacturers** (LIMITLESS) searching Innovative SW solutions integration, opportunistic investment allocation for End-To-End solutions provision;
  - **Smart Homes / Communities Services Providers** (GDF) so as to acquire complementary multimedia partnerships and innovative cost-effective SW/HW platforms integration which will allow customisable multimedia and domotic offer and ultimately new business models emerging from new customer needs.
- In-flight entertainment: negotiations have been initiated with African airliners (Nigeria, Cameroon) towards the introduction of an in-flight multimedia solution launched at CES 2014;
- **Multimedia in hotels & hospitality residences:** the Livemax™ Video Adaptation solution launched in early 2014 by LOCATEL in several 5-star hotels across France and the UK is based on ***My eHome***® architecture.

4.4.4.3. Future Intelligence Ltd (FINT)

FINT's role in T-Nova focuses on the development of an FPGA SoC-based compute node which can be seamlessly integrated into the existing cloud infrastructure. This class of Programmable Cloud Platforms (PCPs) will form a new business line within the company, which will aim at marketing them to cloud providers for integration into their infrastructure. This will allow them to optimize the performance and power profiles of selected application while reducing their Total Cost of Ownership.
Furthermore, the PCP platform developed under T-Nova is being used in order to enhance FINT's existing product portfolio by coupling with existing solution in the IoT domain in order to augment their efficacy. In that role the PCP platform offers advanced analytics capabilities which are located close to the metal, meaning next to the mist network of IoT devices. Thus it brings the increased performance capabilities of programmable logic to existing solution like FINT's Smart Cities management platform.

Impact

The T-Nova programmable logic device solution will significantly boost performance in hyperscale data centers and additionally provide the means for data center operators to reign in power consumption by choosing the appropriate sweet spot between the two metrics. This will be a much-needed help in the effort to deal with the growing data deluge which the current interconnected world produces. Along these lines, apart from raising performance for existing application, FINT's platform can also enable new applications that make used of the unprecedented mass of data currently available in today's data centers.
For an SME like FINT, the Programmable Cloud Platform will significantly improve its competitiveness in this market by providing it with an innovative platform in which it'll have a dominant, solitary position in the market. This platform will not only help further FINT's business goals but it'll also provide a stepping stone to further innovations and RnD activities in this area.

4.4.4.4. CloudStreet Oy (CLDST)

CLDST aims to exploit the T-NOVA know-how in order to enhance Bandwidth Exchange Marketplace product, with additional network services, based on NFV related products. Furthermore, CLDST intends to integrate the Business Service Catalogue (BSC) module developed in the context of T-NOVA, in order to use it, as an inventory database where NFV based network services can be created / combined / traded and provisioned to different network technologies through CLDST Capacity Exchange platform.

Additionally, CLDST is developing a new network capacity exchange platform for Mobile Broadband networks, in order to perform on demand mobile capacity reservation and prioritisation, based on location and time, in order to support complex services such as those envisioned for 5G service networks. T-NOVA modules such as, BSC, Service Composition and Service Selection will be used and enhanced in order to support new extended platform and the new business models that will be developed.

4.5. Academic Exploitation

Academic exploitation is mostly carried out by universities and research institutes and aims to explore novel approaches and innovative solutions, addressing the technical challenges that the project is focusing on as well as answering open technical questions. Academic partners are aiming to focus and intensify their activities in thematic areas of interest for both the industrial and research communities building at the same time strong technical expertise and presence in the relevant fields. In addition, they are interested in the creation of relevant intellectual property as well as in transferring associated knowledge and know how to enhance their education and training activities.

4.5.1. Higher Education

4.5.1.1. Gottfried W. Leibniz Universität Hannover (LUH)

LUH has already published project results at prestigious conferences (e.g., IFIP Networking, IEEE COMSNETS) and journals (IEEE Transactions on Network and Service Management)

LUH is exploiting the results, technologies and approaches developed within T-NOVA in presentations, seminars, and invited talks. LUH further promotes the integration of technical developments from T-NOVA into university courses from which a very large number of students will benefit each year.

Impact: This is expected to increase the visibility of T-NOVA project and we further expect to gain higher reputation, increasing our ability to hire more competent research and academic staff.

We expect to further increase the number of students enrolled to courses and allow the students to acquire practical experience with NFV and SDN.

4.5.1.2. Tech. Ed. Institute of Crete (TEIC)

TEIC plans to exploit the T-NOVA know-how in order to enhance its educational and training activities, both in undergraduate/postgraduate level courses, and offer its students state-of-the-art solutions and practices

in Future Internet technologies. VNFs design, implementation, deployment and exploitation will constitute part of a new curriculum that TEIC aims to offer within the Life Long Learning Framework, utilising formal and non-formal learning procedures. Furthermore, the laboratory-based test-bed infrastructure that TEIC possesses will be enhanced with NFV services, packet inspection-related VNFs and security-oriented VNFs through which students may experiment and get hands-on experience. Last but not least, TEIC intends to leverage the T-NOVA architecture by developing innovative cutting-edge Network Functions as software modules, which can be included in the Function Store, and rapidly introduced to the market, thus avoiding the delay and risk of hardware integration and prototyping.

Impact: TEIC anticipates that the T-NOVA solution is expected to enhance the role of education and its strategic importance for growth, job creation, and social progress, by enabling young graduates and new scientists to become implicit VNF providers who leverage the proposed architecture for developing innovative cutting-edge Network Functions as software modules, and trade/merchandise them through the envisaged Marketplace.

4.5.1.3. University of Milan (UNIMI)

UNIMI is organising seminars on the usage of hardware accelerators such as GPU's (Graphic Processing Unit) for video and image processing showing, as a particular use case, the video transcoding unit (vTU) developed in T-NOVA. UNIMI also offers courses and seminars on both theory and techniques concerning HPC (High Performance Computing), with applications to big-data or computationally-intensive tasks, typically arising in datacenter-like infrastructures. Other topics related to the project are the study and development of combinatorial optimisation algorithms and heuristics for solving complex problems, such as optimal routing and resource mapping.

Impact: The main aim of UNIMI is to generate interest and spread knowledge, among students and researchers, on the main topics involved in the project, such as efficient GPU computing and general practice on HPC, in the fields of video processing and operative research problem solving. Furthermore, UNIMI aims to instruct young graduates, researchers and scientists to face with the new technologies and the new areas of investigation explored in T-NOVA, such as cloud infrastructures, datacenter virtualisation, optimal resources deployment and hardware-accelerated computing.

4.5.1.4. Zurich Univ. of Applied Sciences (ZHAW)

ZHAW organises biannual workshop on SDN topics together with SWITCH in Switzerland. The lastworkshop took place in Zurich, onNovember 13th 2015. The topics covered included: SDN and Network Functions Virtualisation (NFV) advanced architectures, services and use cases; SDN controllers, test beds and experimentations; SDN/NFV-aided service orchestration, network deployment and management, cloud traffic optimisation; Software Defined (SD) Data centres including NFV integration in Data centres; Software Defined Storage and Software Defined Security; OpenDaylight based SDN contributions. Service Function Chaining in SDN; SDN networking for Docker containers; Software Defined 5G Networks and Operations, Business considerations and economic aspects in SDN.

Impact: The aim of the SDN workshop is to share knowledge, have hands on sessions/presentations on Software Defined Networking (SDN) research and implementation of novel applications and solutions, providing a complete picture of ICT approaches, industry solutions, innovation and research. This improves the SDN know-how on the current

technologies, which helps ZHAW stay updated and align with important contributions from the academy and the industry. This increases the quality of work to be developed as important aspects / technologies might be envisioned and further addressed / utilised in the provided contributions. On the other hand, T-Nova specific implementations and contributions can be further presented to the SDN community and third parties and thus increase the impact and give visibility to the project results.

4.5.2. Research Centres

4.5.2.1. NCSR Demokritos (NCSRD)

In the course of the project so far, NCSRD has already partially implemented the exploitation plan laid out in the DoW. In specific, NCSRD has built (and is still building) significant expertise and specialisation in software-defined future networks which has enabled the research team to successfully participate in EU-funded projects (also within the 5G programme) related to virtualisation and NFV, not only gaining access to additional funding for further research - but also strengthening the technical excellence of the lab in the sector.

Indeed, via the participation in T-NOVA, NCSRD personnel have gained invaluable insight into the NFV advances and technical details. This is achieved mainly thanks to the interaction with expert partners in the field (within but also outside the project, via communication/dissemination activities), as well as the heavy technical involvement in integration and experimentation activities in the NCSRD cloud network testbed.

With regard to the infrastructure, NCSRD is exploiting T-NOVA as opportunity to expand and enrich the current OpenStack lab infrastructure with additional nodes, SDN switches and high-speed network equipment in order to significantly enhance the experimentation capacity of the lab.

Finally, regarding results commercialisation, NCSRD is already in contact with spin-off companies, which can help to commercialise the project outcomes, especially focusing on the vTC (virtual Traffic Classifier) VNF.

SDN and NFV, thanks to their software nature, present excellent opportunities for academic partners, like NCSRD, to experiment and produce innovative results, which can be rapidly commercialised. The exploitation activities planned by NCSRD are mainly towards this direction, i.e. accelerating market uptake of T-NOVA results via commercial channels. This is a contribution to the overall envisaged impact of SDN and NDV regarding promotion of market openness.

4.5.2.2. Fraunhofer FOKUS (FRAUNHOFER)

Participation in the T-NOVA project provides FRAUNHOFER the unique opportunity to share expertise with the project partners in security and virtualisation. These synergetic opportunities will allow FRAUNHOFER to shorten the R&D cycle of its testbeds and products, mainly in the area of cloud computing and security. The close collaboration between FRAUNHOFER and various industrial partners will ensure that the project receives useful feedback from major network and service providers, regarding trial results, marketing opportunities, user benefits and wide-scale implementation feasibility.

Impact: FRAUNHOFER will first of all exploit T-NOVA results in other projects related to clouds, identity management and IP-Security. In addition to that, the knowledge acquired within this project will be passed to graduate students and researchers through lectures and seminars

4.5.2.3. Consorzio per la Ricerca nell'Automatica e nelle Telecomunicazioni (CRAT)

CRAT organised seminars at the University of Rome "Sapienza". T-NOVA project was presented during lectures of the course on "Control of Communication and Energy Networks", within the Master in Control Engineering. A PhD student in System Engineering started his PhD research on the topics addressed by the project. His work was focused on the design and implementation of a load balancing algorithm among SDN controllers in clustered scenarios. Moreover, several students of Bachelor and Master Degree in Computer Systems are developing their thesis in topics related to T-NOVA, as regards load balancing and service mapping algorithms. CRAT also started collaboration with industrial partners; both national and international, to discuss about topics addressed by T-NOVA and prepare future initiatives in SDN/NFV context.

Impact

T-NOVA will improve technical skills of involved personnel, opening the way towards wider interactions with Telco operators, also building a strong community around SDN, NFV and Cloud technologies.

4.5.2.4. Fundació i2CAT, Internet i Innovació Digital a Catalunya (i2CAT)

i2CAT directly participates in the NFV Orchestrator development (TeNOR) implemented in the T-NOVA project. Being a research centre, i2CAT intends to leverage the NFV Orchestrator developed in T-NOVA in order to both offer innovative, value-added services to their current partners (members of the board) and analyse the feasibility of including TeNOR in the on-going 5G research and innovation activities. In this sense, i2CAT works directly with regional partners in order to transfer both technology and knowledge acquired within T-NOVA.

Impact

T-NOVA is currently improving in general the NFV expertise of the network management group at i2CAT, both in terms of general virtualisation and NFV know-how, and in terms of active standardisation groups around the NFV topic (e.g. ETSI NFV, IRTF NFVRG). T-NOVA developments are directly impacting in the innovation consultancy services portfolio of the research centre, since they are enabling to include orchestration and NFV-related services.

5. CONCLUSIONS AND FUTURE WORK

NFV is a game changer in the telecommunications industry. It promises new business goals, reduction of CAPEX and OPEX, acceleration of innovation, and improved time to market.

The T-NOVA solution is expected to be an attractive revenue source for European network/telecom service providers, who are able to monetise on their infrastructure by offering new services and by charging customers according to the actual usage of in-network resources, as opposed to claiming low, flat fees for plain connectivity services providing applications "over-the-top" with no QoS guarantees and no in-network treatment.

Surveys relating to NFV adoption indicate telecom operators are aware of the challenges and as a consequence has certain anxieties relating to its rollout. It is expected that the timeline for NFV adoption is getting shorter compared to last year's 2014 survey results. Telecom operators are expecting 2017 to be the year of NFV trial explosion.

With respect to the challenges of the NFV learning curve and the lack of qualified staff, the T-NOVA platform includes a dashboard for all users (providers and customers) to making the use of NFV easier and understandable, which of course fosters faster uptake and facilitates the familiarity with the technology.

As for the coexistence of legacy and NFV, this is still a work in progress in terms of of the adoption path and the impact on legacy systems as NFV is deployed, including the orchestration aspects in scenarios in which virtualised and non-virtualised elements have to cooperate.

The next and final version of this deliverable (D8.13) aims to address objective 9. The upcoming deliverable will study a business model and elaborate on the associated business models for the T-NOVA architecture addressing all the involved actors. More specifically:

- D8.13 will elaborate a detailed business plan for the involved actors towards adopting the T-NOVA architecture and recommendation after having the output/results of the project.
- D8.13 will design a T-NOVA adoption survey to run through the final year of the project. The survey will aim to capture the views of the respondents regarding their approach to implementing NFV and the adoption the T-NOVA solution, identify the primary factors that will drive their organisation's interest in T-NOVA along with the factors that will reduce their interest in T-NOVA.

6. LIST OF ACRONYMS

Acronym	Explanation
5G	5th Generation Mobile Networks
BSS	Business Support Systems
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CDN	Content Defined Network
CSP	Communication Service Provider
ESP	Evolved Service Platform
ETSI	European Telecommunications Standards Institute
QoS	Quality of Service
IaaS	Infrastructure as a service
IHS	Information Handling Services
IT	Information Technology
IP	Intellectual Property
ISG	Industry Specification Group
ISV	Independent Software Vendors
NFV	Network Functions Virtualisation
OCP	Open Compute Platforms
OPEX	Operational Expenditure
OTT	Over-The-Top
OVS	Open vSwitch
OSS	Operations Support System
PaaS	Platform as a service
PNF	Parallel Network File
PoCs	Proof of Concept
SDN	Software Defined Network
SLA	Service Level Agreement
SWOT	Strengths, Weaknesses, Opportunities, Threats
TTM	Time-To-Market
VNE	Virtualised Network Environment
WP	Work Package

7. REFERENCES

[1] HP - Manage the future now - Transforming operations for network functions virtualization - Business white paper

[2] Network Virtualization & SDN World 2014: CSPs confirm Analysys Mason's NFV and SDN forecasts – Analysys Mason website [Online] http://www.analysysmason.com/About-Us/News/Insight/NFV-SDN-forecasts-Jun2014-RMA16/#sthash.Gn15avZr.dpuf

[3] Gartner - Forecast Analysis: Communications Service Provider Operational Technology, Worldwide, 2Q15 Update - Gartner Website [Online] https://www.gartner.com/doc/3096026/forecast-analysis-communications-service-provider

[4] Mind Commerce - Mind Commerce Website [Online] http://www.mindcommerce.com/network_functions_virtualization_(nfv)_market_business_case_market_analysis_and_forecasts_2015__2020.php

[5] Infonetics - Infonetics Website [Online] http://www.infonetics.com/pr/2015/NFV-Market-Highlights.asp

[6] FierceWireless - Study: NFV market will hit $11.6B in 2019 [Online] http://www.fiercewireless.com/tech/story/study-nfv-market-will-hit-116b-2019/2015-07-20

[7] HP - Cloud Computing - HP Helion [Online] http://www8.hp.com/us/en/cloud/helion-overview.html

[8] Alcatel Lucent - CloudBand 3.0: The production platform for NFV [Online] https://www.alcatel-lucent.com/solutions/cloudband

[9] FusionSphere - FusionSphere Cloud Operating System [Online] http://e.huawei.com/en/products/cloud-computing-dc/cloud-computing/fusionsphere/fusionsphere

[10] Cisco - Network Automation - Evolved Services Platform [Online] http://www.cisco.com/c/en/us/solutions/service-provider/evolved-services-platform/index.html

[11] Juniper Networks – Contrail [Online] http://www.juniper.net/us/en/products-services/sdn/contrail/

[12] CENX – CENX Cortx Overview [Online] http://cenx.com/products/cortx-service-management-assurance-for-sdn-nfv/

[13] Nokia - Telco Cloud [Online] http://networks.nokia.com/portfolio/solutions/telco-cloud

[14] ETSI ISG NFV Whitepaper, October 2012: [Online]: http://portal.etsi.org/NFV/NFV_White_Paper.pdf

[15] Gigaom Research: NFV Adoption to Transform Telecommunications Infrastructure, 2014

[16] Strategyzer - [Online] Business Model Canvas https://strategyzer.com/canvas?_ga=1.117393990.1544303236.1449829092

[17] HP - Fact Sheet - 2015 HP Survey of NFV priorities

[18] EuroComms - SDN/NFV: European Commununications survey highlights [Video] [Online] http://www.eurocomms.com/video/sdn-nfv/10657-sdn-nfv-european-commununications-survey-highlights

[19] Thijs Metsch, Olumuyiwa Ibidunmoye, Victor Bayon-Molino, Joe Butler, Francisco Hernández-Rodriguez, and Erik Elmroth. 2015. Apex Lake: A Framework for Enabling Smart Orchestration. In Proceedings of the Industrial Track of the 16th International Middleware Conference (Middleware Industry '15). ACM, New York, NY, USA, , Article 1 , 7 pages. DOI=http://dx.doi.org/10.1145/2830013.2830016