NETWORK FUNCTIONS AS-A-SERVICE
OVER VIRTUALISED INFRASTRUCTURES

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Standards Tracking and Contribution

Final Report on Standardisation Activities

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Executive Summary

This deliverable presents the standardization activities and results undertaken during the T-NOVA project as part of Task 8.2.

The document is a report providing information on the standardization bodies, working groups and fora which were monitored, describes the progress within these groups and contributions which were submitted on behalf of T-NOVA project.

Due to the innovative nature of the T-NOVA project, standardization activity is considered an important objective and most of the partners are active in standardization through various bodies, working groups and committees.

The document outlines in Chapter 2 the initial standardization plan for proactive contributions to a number of very important standardization organizations. Chapter 3 and 4 provide a plan for the standardization activities and a standardization strategy. The list of relevant standardization organization is included in Chapter 5, providing a list of the key standardization target of T-NOVA, such as ETSI NFV ISG (Industry Specification Group) and many others.

Chapter 6 and 7 provide the list of topics and the list of the contributions submitted by T-NOVA partners during the project.

Chapter 8 provides information on the possible future work to be performed by the partners after the end of project.

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1. INTRODUCTION

T-NOVA introduces specific innovations in several fields of contemporary research such as federated network and cloud management, Network Functions Virtualization, Software Defined Networking, programmable networks, future network architectures and network service brokerage. All the aforementioned fields are being addressed by several focused activities within local and global standardisation organisations.

A primary aim of T-NOVA was to reinforce the presence and role of Europe in these research fields.

Following the recommendation by EC, T-NOVA planned to follow a proactive plan for contributions to a number of very important standardization bodies and committees.

More specifically T-NOVA considered the importance of Network Function Virtualization (NFV) and Software Defined Networking (SDN) as key emerging areas for the implementation of future networks. The application of NFV and SDN requires research and experimentation in order to implement new network services on virtualized infrastructures.

Standardization and the experimentation of Open Source Software solutions can play an important role in the acceleration of use of the NFV and SDN technologies for the availability of new services.

Standardization is important for service providers in order to have interoperable solutions provided by different vendors that can operate in an open ecosystem, in order to avoid the so called "vendor lock-in".
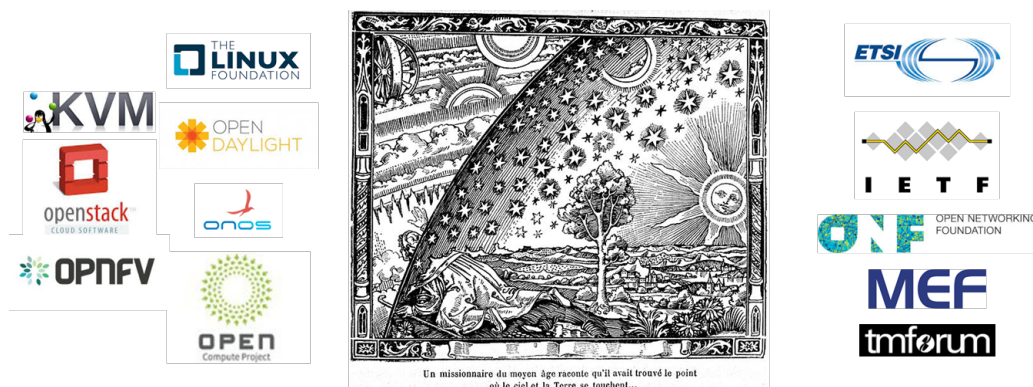
Figure 1 – Standardization and Open Source Software

In this context the open source solutions (seeFigure 1) can provide two things:

1) They can be used for implementing solutions that can be adopted in real networks. It should be noted that the adoption of open source solutions is now taken into account by the Communication Service Providers;

2) They can provide the experimentation that is fundamental for the definition of the standards. It is not possible to have good standard without "experimentation".

Important initiatives are undergoing under the Linux Foundation like OPNFV, the Open Platform for NFV and for the SDN controllers: ONOS and Open Daylight.

Future networks will provide extraordinary performances. For instance, 5G networks in mobility will provide latency below 10 msec and bandwidth above 100 Mbps.

This provides the opportunity for implementing new services, services that are not feasible with the current networks such as connected cars, virtual reality, tactile Internet, etc. It will be also possible to improve existing communications services, for instance providing a higher video definition. The role of NFV and SDN and the implementation of marketplaces will be fundamental for fostering innovation and providing these new services.

2. INITIAL STANDARDISATION TARGET

The principal standardisation target of T-NOVA distinguished during the initial phases of the project is the ETSI NFV ISG (Industry Study Group), in which four of the T-NOVA consortium participants were already active members: HP (now HPE), Intel, Italtel, Portugal Telecom (now AlticeLabs) and Demokritos.

The NFV ISG is the leading standardisation organization in the NFV field worldwide, and all the major network operators from around the world are represented. The scope of the ISG working groups in ETSI Phase 1 (i.e.: Management and Orchestration, Infrastructure, Software Architecture, Reliability and Availability, Performance) clearly corresponded to key activities within the T-NOVA workplan.

Specific contributions from T-NOVA were planned including:

- NFV MAN WG (Management and Orchestration) from WP 3. WP3 leader (PTIN) is participating in the MANO WG and will align WP3 activities with WG progress;

- NFV INF WG (Infrastructure) from WP 4;

- NFV SWA WG (Software Architecture) from WP 5;

- NFV REL WG (Reliability and Availability) from WP 3 and 4;

- NFV PER WG (Performance) from WP 5.

In addition to NFV ISG, contributions to other standardization activities were planned per partner as follows:

- VIO contributions to HGI (Home Gateway Initiative) aspects on Home Gateway virtualization.

- PTL contributions to IETF SDN Initiative the results of the SDN Control Plane definition and development.

- CLDST contributions for the network brokerage aspects to the Metro Ethernet Forum (MEF) and the Tele Management Forum (TMF).

- INTEL planned to communicate project results on cloud management for NFV to the international standards initiatives in which the Cloud Services Lab personnel participates, such as the national ISO sub-committee mirror groups, the European cloud standards working groups, and the global ISO sub-committees (e.g. ISO SC38 – Cloud Computing). The lab also occupies a leadership role (co-chair) in OGF's Open Cloud Computing Interface working group, and has engaged in the ETSI Cloud Standards Coordination initiative.

3. STANDARDIZATION PLAN

The standardization plan was presented in the meeting held in Carini (Italy) in October 2014, and it is based on the following actions and rules.

The leader of the standardisation task (task 8.2) is in charge of the overall coordination of standardisation activities in the project.

The task leader will maintain and update the list of:

- Relevant SDOs/WGs covered.
- Reference persons: based on the knowledge of status of work he/she can help to be more effective.
- Opportunities for contributions identified by the Leaders of technical WPs.

The Task 8.2 leader (ITALTEL) in collaboration with the reference person(s) for the various SDOs/groups shall maintain and update Wiki with the:

- List of topics where concrete opportunities for contributions,
- List of contributions under preparation,
- Status of current work,
- List of submitted contributions, main achievements, etc.

The Work Package Leader or the other participants in the project:

- Notify the identified opportunities at an early stage to the Task8.2 leader and to the SDO/WG reference person(s).

SDO/WG reference person:

- Assists author(s) of standard contribution during the preparation of the submission.
- Coordinate work of different project partners,

Author(s):

- Share draft contributions over the WP8 mailing list before submission, to gather comments and possibility for co-signing.
- Announce over the WP8 mailing list results of the submission of contribution (acceptance, revision and/or reject).
- Provide information gathered during the discussion of the contribution(s), as guidance for future project work.

4. COMPREHENSIVE STANDARDIZATION STRATEGY

We focus here on the concrete relation and value of the standardization activities for the project. The objective is to explain the interrelation of the contributions and their impact and importance for T-NOVA and provide an answer to the questions raised during the Technical Review.

NFV and SDN were introduced aiming at achieving service agility, allowing innovation and making possible to implement new business models. T-NOVA project started at the very beginning of the ETSI NFV activities so it was necessary to introduce and develop the new concept with a disruptive approach. At the same time, it was equally important to follow the development of the standards so to provide the possibility to implement the innovation in the Telco environment where it is necessary to achieve interoperability between solutions provided by different vendors.

In the elaboration of the standardization strategy we verify the existence of two different approaches:

- T-NOVA proposes objectives that can be considered as a "Game-changing" innovation;
- The approach for standardization anyway is Incremental.

Game-changing means focusing on something new, creating new markets and enabling new business models with the introduction of radical technology changes.

Respect to this, not everything shall be standardized. In fact, many innovations in the web are not guided by standards. For instance, it is possible to compare the initiatives for RCS (Rich Communication Services) activated by the Telcos and the great availability of messaging and voice applications provided by OTTs, available without charges for the end users. A lot of work was necessary for the development of specific standards for RCS, based on the IMS platform and the standardization process requested years to be completed. On the other hand, OTTs had the chance to launch very quickly new solutions, gaining the favour of end-users. Needless to say, the drawback is the impossibility to interoperate among the different available solutions.

The incremental approach, therefore was considered because it is necessary to keep in track with the evolution of standards that makes possible to adopt the new solutions proposed by the project in standard-based networks, where the interoperability is guaranteed.

Therefore, the approach was a pragmatic one and the standardization strategy was based on an evolutionary path:

- considering the need to find the gaps in the existing standards in order to improve them;
- mainly focusing on the evolution of current available standards in order to provide the basis for the implementation of the T-NOVA architecture and functional requirements in an open environment.

It was not considered an objective to provide a complete standardization for the full T-NOVA framework. This is not an objective in contrast with the game-changing, or at

least disruptive, approach but simply because it was not requested the provide interoperability between different implementation of the Marketplace.

On the contrary it was necessary to work on the gaps individuated in current standards in order to implement the T-NOVA Marketplace concept in an environment that is based on consolidated standards.

During the initial phase of the project the following activities were performed:

- Analysis and tracking of the standardization, with the participation to on-line meeting and, whenever possible to face to face and plenary meeting;
- Analysis and tracking of the open source communities with the evaluation of OpenDayLight and OpenStack;
- Gap analysis;
- Elaboration of specific contributions.

During the first phases of the process it was also important to perform experimentations, within specific test labs, on the fundamental concepts constituting the base of NFV, such as data plane acceleration techniques.

The work in task 8.2 was structured around these main concepts.

In particular, WP2 dealing with the overall system architecture and subsystem specifications was strictly related to the evolution of the standardization in ETSI. It was important to establish a dependency on the ETSI reference framework, at the same time introducing specific innovations.

The objective was to individuate the grey areas in which it was important to provide contributions that were deemed mandatory or anyway important for the project and in particular:

- Descriptors: the definition of VNF and NS descriptors is really important in order to include the information elements that are important for the project and obtain a coherent modelling. In this case the progress of the specification was not in line with the project timeframe, so it was possible to provide contribution in the initial phase for the discussion on the VNF descriptor and it was supported the individuation of a new Work Item for the Network Service description. The definition of the standards is undergoing.
- Multi-tenancy: it was considered mandatory to achieve within the ETSI NFV standards the definition of an environment in which virtualized resources are shared not only by different VNFs and NSs but also by different tenants and organization running their VNFs/NSs. This concept was really important for T-NOVA due to the fact that the marketplace can be accessed by different organization in order to provide services. The concept is equivalent to the Cloud as a Service one that is rapidly evolving. Specific contributions were submitted and approved.
- Assurance and healing: it was important to provide contribution for the discussion on the assurance and healing considering the possibility to apply

recovery mechanism in case of failures of a VNFs. The concept is important in order to establish SLA with the customers of the Marketplace.

- Evolution and Ecosystem: participation to the definition of SDN use cases was definitely important because T-NOVA adopt network solutions based on SDN.
- Geographical distribution: one of the most important concept is the possibility to have a geographical distribution of VNFs in order to implement Network Services spanning over multiple NFVI point of presence.
- HW acceleration: Transcoding improved by the usage of HW acceleration is important for the implementation of one of the target VNFs. In the starting phase in ETSI NFV there was the belief that everything could be implemented by SW. With the passing of time, it was evident and confirmed with the testing activities in T-NOVA, that the usage of HW acceleration was mandatory to achieve the required performances limiting the excessive use of virtualized resources. It was proposed a specific contribution for the enabling of Transcoding based on HW acceleration.
- Marketplace: considering the marketplace innovation, it is important to note that the full standardization of the concept is not taken into account by ETSI NFV because the scope of the ISG doesn't include it in its scope. Some initiative is in progress in the TMForum environment and we are redirecting our effort;
- Open source communities: It is important to have a standardization process for assuring interoperability but the problem is that this process takes time. Open Source Communities are gaining importance and it is necessary to take into account their achievement in order to obtain successful standard specifications. Usually standardization is a long journey while the Open Source adopts an agile approach based on continuous integration and delivery.

In the following table we provide the list of T-NOVA Work Packages and the corresponding links to the activities performed in Task 8.2.

WP	WP Objective	Links with task 8.2
WP2	System Specification	The objective of WP2 is the definition of the overall system architecture and the specifications for the functional entities.
		This objective was reached by taking into account the reference specifications (mainly focusing on ETSI NFV ISG guidelines).
		The link with T8.2 consists in providing an input to this task, individuating the specific contributions to submit so to fill the existing gaps between the existing standards and T-NOVA architecture.

WP3	Orchestration Platform	The objective of WP3 is the implementation of the management and orchestration framework in T-NOVA. The link with T8.2 was similar to the one established in WP2, considering aspects related to the definition of NFV descriptors.
WP4	Infrastructure Virtualisation and Management	The objective of WP4 is related to the activities performed in T8.2 in the Evolution and Ecosystem Working Group in ETSI that originated an important contributions on the distributed NFV environment.
WP5	Network Functions	The objective of WP5 is related to the activities performed in T8.2 in the Interfaces and Architecture Working Group in ETSI that originated the contributions on the HW acceleration for Transcoding functions.
WP6	T-NOVA Marketplace	The objective of WP6 is related to the activities performed in T8.2 that originated a specific contribution on the Marketplace. Considering that the Marketplace and business aspects can be an input to TMForum, other contributions will be submitted to this Standardization organization.
WP7	Pilot Integration and Field Trials	It is expected to take advantage from the activities perfomed in this WP in order to provide specific contributions.
WP8	Dissemination, Standardisation, Exploitation and Training Activities	Task 8.2 belongs to this WP.

5. LIST OF THE RELEVANT SDOS/WGS

Table 1 provides the list of the relevant SDOs/WGs covered in the T-NOVA project.

Table 1 – List of relevant SDOs and Open Source communities

SDO/OSS	
ETSI NFV ISG	ETSI Network Function Virtualization Industry Specification Groups
IETF	Internet Engineering Task Force
IRTF	Internet Research Task Force
ISO/IEC	International Organization for Standardization
ONF	Open Networking Foundation
MEF	Metro Ethernet Forum
TM Forum	TM Forum
OpenStack	
OpenDaylight	
OPNFV	Open Platform for NFV
HGI	Home Gateway Initiative

The following section provides specific information for each group.

5.1. ETSI NFV ISG

ETSI NFV ISG (Network Function Virtualization Industry Specification Groups), the ETSI group for network functions virtualization, was created by world's leading Telcos, joined by other network operators, TEMs, IT vendors and technology providers. The group aims at providing requirements and architecture specifications for the HW and SW infrastructure required to support the virtualization of network functions and the guidelines for developing virtualised network functions.

NFV addresses the consolidation of many network equipment types onto industry standard high volume servers, switches and storage, in Data Centres, Network Nodes, end user premises leveraging standard IT virtualisation.

NFV applicable to any data plane packet processing and control plane function in fixed and mobile network infrastructures. NFV is highly complementary to SDN but not dependent on SDN.

The group was initiated at the end of 2012 after the submission of a White Paper written by seven of the world's leading telecoms network operators. The ISG is based on a large community of experts working intensely to develop the required standards for "Network Functions Virtualisation". The membership of ISG NFV has grown to over 230 individual companies including 37 of the world's major service providers as well as representatives from both telecoms and IT vendors.

The output of ETSI NFV Phase 1 is constituted by the following public available published documents on ETSI portal (see [DOC]):

- Architecture: Architectural Framework;
- Use cases;
- Terminology;
- Infrastructure: Overview; Compute Domain, Hypervisor Domain, Network Domain, Service Quality Metrics;
- Management: Management and Orchestration;
- Performance: Performance and Portability Best Practices;
- Reliability: Resiliency Requirements;
- Security: Security problem statement; Security and Trust Guidance.

The guidelines for Phase 1 were mainly based on Informative requirements in order to provide guidance and generate consensus on general architecture and general requirements.

Many PoCs were also fostered in order to encourage the growth of the eco-system.

With Phase 2 the focus was "interoperability", i.e. the capability to implement a solution assembling components in an open ecosystem. The target for specification was also to provide normative requirements and not only informative ones. Specifically, the normative requirements were intended according the need to define different levels of detail spanning from the High level service definitions to the definitions of the Information Elements in the protocol interfaces.

The structure remained based on WGs and Task Forces extending functionalities of previous WGs: MANO, SWA, INF.

Additional information can be found at the following link: [NFV].

5.2. Internet Engineering Task Force

Internet Engineering Task Force (IETF) (see: https://www.ietf.org/) is the organization developing and promoting Internet standards. The IETF is organized into a large number of working groups and informal discussion groups dealing with specific topics.

5.3. Internet Research Task Force
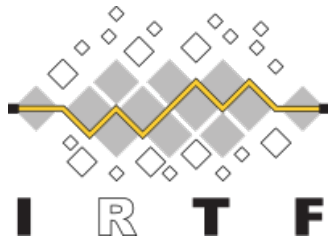
The Internet Research Task Force (IRTF) (see: https://irtf.org/) focuses on longer term research issues related to the Internet while the parallel organization, the Internet Engineering Task Force (IETF), focuses on the shorter term issues of engineering and standards making.

The following are those relevant for T-NOVA:

- NFVRG (Network Function Virtualization Research Group)
- SDNRG Software Defined Networking Research Group

The Network Function Virtualization Research Group (NFVRG) has the objective to bring together researchers and grow the community around the world in both academia and industry to explore the technologies enabling the virtualization of network functions.

The NFVRG focus on research problems associated with NFV, in correlation with other IRTF groups (e.g. SDNRG) and standardization activities of IETF WGs (e.g. SFC). A brief summary of the areas of interest include: new network architectures based on VNFs; Network and Service Function Chaining; Autonomous orchestration and optimization; Reliability; Security; Performance modelling; New operational models; Infrastructure and NF description and programming; Virtualized network economics and business modeling, etc.

Near-term work items are the following: Policy-Based Resource Management (focusing on optimized resource management and workload distribution based on policy); Analytics for Visibility and Orchestration (focusing on techniques for the applicability of real-time analytics); Virtual Network Function (VNF) Performance Modeling to Facilitate Transition to NFV; Service Verification with Regards to Security and Resiliency.

Relevant information and research developed by the research group will be submitted for publication as Experimental or Informational RFCs.

Additional information can be found at the following link: [NFVRG].

The Software-Defined Networking Research Group (SDNRG) addresses many open issues in the research in the SDN area, investigating SDN from various perspectives aiming at identifying the approaches that can be defined and implemented in the near term as well identifying future research challenges.

In particular, the research area includes solution scalability, abstractions, and programming languages and paradigms in the context of SDN. SDNRG aims also at providing objective definitions, metrics and background research with the goal of providing this information as input to protocol, network, and service design to other standardization organizations.

The areas of interest are the following: Classification of SDN models; SDN model scalability and applicability; Multi-layer programmability and feedback control systems; System Complexity; Network description languages, abstractions, interfaces and compilers; Security.

Additional information can be found at the following link: [SDNRG]

5.4. ISO/IEC

The scope of ISO/IEC JTC 1/SC 38 is the "Standardization for interoperable Distributed Application Platforms and Services." [2] This includes: Web services; Service Oriented Architecture (SOA); Cloud computing.

Additional information can be found at the following link: [ISO]

5.5. Open Networking Foundation

Open Networking Foundation (ONF) is a user-driven organization dedicated to the promotion and adoption ofSoftware-Defined Networking (SDN) through open standards development.

https://www.opennetworking.org/

Additional information can be found at the following link: [ONF].

5.6. Metro Ethernet Forum

MEF is a global industry alliance comprising more than 220 organizations including telecommunications service providers, cable MSOs, network equipment/software manufacturers, semiconductors vendors and testing organizations. The MEF's mission is to accelerate the worldwide adoption of Carrier-class Ethernet networks and services.

Additional information can be found at the following link: [MEF].

5.7. TM Forum

TM Forum has created ZOOM (Zero-touch Orchestration, Operations and Management project) to create a living blueprint for a new generation of service provider support systems to deliver true business agility, and expert guidance on how to to get there.

Additional information can be found at the following link: [TMFORUM].

5.8. OpenStack

OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter, all managed through a dashboard that gives administrators control while empowering their users to provision resources through a web interface.

Additional information can be found at the following link: [OS].

5.9. OpenDaylight

OpenDaylight is an open platform for network programmability to enable SDN and create a solid foundation for NFV for networks at any size and scale.

Additional information can be found at the following link: [ODL].

5.10. Open Platform for NFV

OPNFV is an open source project focused on accelerating the evolution of NFV.

OPNFV will "establish a carrier-grade, integrated, open source reference platform that industry peers will build together to advance the evolution of NFV and to ensure consistency, performance and interoperability among multiple open source components". The initial scope of OPNFV will be on building NFV Infrastructure (NFVI), Virtualized Infrastructure Management (VIM), and including application programmable interfaces (APIs) to other NFV elements, which together form the basic infrastructure required for Virtualized Network Functions (VNF) and Management and Network Orchestration (MANO) components.

The project was announced on September 2014 by the Linux Foundation.

The goal of OPNFV is to accelerate the introduction of new NFV products and services. As an open source project it is positioned to bring together the work of standards bodies, open source communities and commercial suppliers to deliver a "de facto" standard open source NFV platform for the industry. By integrating components from upstream projects, the community is carrying out performance and use case-based testing to ensure the platform's suitability for NFV use cases. OPNFV aims also to bring

the learnings from its work directly to those communities in the form of blueprints, patches, and code contributions.

The scope of OPNFV's ARNO release (June 2015) was focused on building an NFV Infrastructure (NFVI) and Virtualised Infrastructure Management (VIM) by integrating components from upstream projects such as OpenDaylight, OpenStack, Ceph Storage, KVM, Open vSwitch, and Linux. These components, along with application programmable interfaces (APIs) to other NFV elements form the basic infrastructure required for VNFs and Management and Network Orchestration (MANO) components. OPNFV's goal is to increase performance and power efficiency; improve reliability, availability, and serviceability; and deliver comprehensive platform instrumentation.

One of the projects in OPNFV is Yardstick. T-NOVA provided contributions to the Yardstick project which were included in the OPNFV Brahmaputra release (available from April 2016).

The goal of the Yardstick Project is to verify the infrastructure compliance when running VNF applications. NFV use cases described in ETSI GS NFV 001 show a large variety of applications, each defining specific requirements and complex configuration on the underlying infrastructure and test tools. The Yardstick concept decomposes typical VNF work-load performance metrics into a number of characteristics/performance vectors, which each of them can be represented by distinct test-cases. The project scope is to develop a test framework, test cases and test stimuli.

Additional information can be found at the following link: [OPNFV].

5.11. Home Gateway Initiative

HGI is shaping the way that services are delivered in the digital home. HGI was founded in 2004 by major Broadband Service Providers (BSPs), and has since been joined by leading manufacturers of digital home devices, chips, and software.

Additional information can be found at the following link: [HGI].

6. LIST OF TOPICS

The list of reference persons for the participation to standardization groups is provided in the Table 2. .

Table 2 – Partners and reference persons

Partner	reference person	
Atos	Ramos Lopez, Aurora aurora.ramos@atos.net	Though according to the DoW ATOS may not contribute specifically to the standardization task, in relation to the standardization bodies identified as relevant to T-NOVA, ATOS is currently active in TMForum.
HP	Marco Di Girolamo marco.digirolamo@hp.com	HP is represented in the ETSI NVF ISG, Open Platform for NFV (OPNFV), OpenDaylight The HP liaisons into these bodies are appointed and managed at corporate level, so our group can't commit to any specific action, since we don't have the right empowerment. For sure, we will seek ways to get internal links, and transfer T-NOVA results to the best suited people.
Intel	Michael J Mcgrath michael.j.mcgrath@intel.com	Active in following relevant standards/industry bodies NFV: Open Platform for NFV ETSI Network Function Virtualization SDN: OpenDaylight Consortium Open Networking Foundation Cloud: OpenStack Foundation Open Cloud Consortium ISO JTC1 (Joint Technical Committee 1) (specific focus on cloud standards such as OVF and OCCI) Intel engagements with standards bodies are appointed and managed at a corporate level also with constraints regarding specific commitments to standards actions.

Italtel	Giuseppe Monteleone giuseppe.monteleone@italtel.com	Italtel participates to ETSI NFV ISG.
Primetel	Michael Georgiades michaelg@prime-tel.com	Subscribed to the following IETF mailing lists: vnfpool (Virtualized Network Function Pool) NSaaS (Network Security as a Service) no WGs established yet for these but they are active discussions of interest also subscribed to these mailing lists: Nfvrg, Sdnrg. Recent nsaas draft is this http://tools.ietf.org/html/draft-dunbar-nsaas-problem-statement-00 discussed here http://www.ietf.org/mail-archive/web/ietf-announce/current/msg13119.html
PTInS	Jorge Carapinha JorgeC@telecom.pt	Altice Labs (formerly PTIN) was active in two standardization fora that can be considered relevant to T-NOVA: ETSI NFV ISG – member of the ISG and member of the NOC (Network Operators Council); TM Forum ZOOM (Zero-touch, Orchestration, Operations and Management) (only partially, as Altice Labs is no longer a TM Forum member).
CLDST	Thomas Pliakas, tpliakas@thecldst.com, Mika Skarp, mskarp@thecldst.com	CLDST is actively participating in Metro Ethernet Forum (MEF) and especially in Service Operation Committee (SOC).

7. STATUS (LIST OF CONTRIBUTIONS)

The list of contributions to standardization activities is provided in the following.

7.1. ETSI NFV ISG

WG	EVE
Partner	Altice Labs (as PT PORTUGAL SGPS SA affiliated company)
Title	Discussion of VIM interconnection scenarios
Description	This document discusses scenarios for SDN across multiple VIM and is especially targeted at section 5.2 of the "Report on SDN Usage in NFV Architectural Framework". Main references are ETSI GS NFV-MAN 001, ETSI GS NFV INF 005 and ONF "SDN Architecture".
Date	2015-01-07
Link	ETSI member only https://docbox.etsi.org/ISG/NFV/EVE/05-CONTRIBUTIONS/2015//NFVEVE(15)000004r3_Discussion_of_VIM_interconnection_scenarios.doc
Status	Approved. Contribution included in ETSI NFV EVE005 report, publication pending.
Relevance for T-NOVA	SDN usage in NFV architectural framework is important considering the objective of Task 4,2 T-Nova SDN Control Plane and specifically Inter-DC/WAN Integration

WG	Other
Partner	Altice Labs (as PT PORTUGAL SGPS SA affiliated company)
Title	Feature Proposal: Integration of VNF with WAN connectivity services
Description	The present contribution proposes the feature "Integration of VNF with WAN connectivity services"
Date	2015-09-14
Link	ETSI member only https://docbox.etsi.org/ISG/NFV/05-CONTRIBUTIONS/2015/NFV(15)FTR024_Feature_Proposal_Integration_of_VNF_with_WAN_connectivity_s.docx File:Feature_Proposal_VNF&WAN.docx
Status	Merged with three other feature proposals around NFV/WAN. The final proposal has been ranked #1, from a list of 21 eligible proposals, by ETSI NFV Network Operators Council (NOC) and later endorsed by the Technical Steering Committee (TSC). The proposal was approved in April 2016 and the work will formally start in the NFV#14 meeting in Atlanta, May 3-6. Results from T-NOVA Task 4.2, especially on the design of the WICM module, will feed this activity.
Relevance for T-NOVA	SDN usage in NFV architectural framework is important considering the objective of Task 4,2 and Task 4.3 and specifically Inter-DC/WAN Integration that is the most innovative objective.

WG	IFA
Partner	Altice Labs (as PT PORTUGAL SGPS SA affiliated company)
Title	NFVI/WAN integration analysis
Description	This contribution is targeted at IFA022 (Section 6) and provides an analysis of the VNFI-WAN integration. It starts by identifying the two major VNF types with regard to VNFI-WAN integration requirements and then describes scenarios for WIM deployment.
Date	2016-08-05
Link	ETSI member only https://docbox.etsi.org/ISG/NFV/IFA/05-CONTRIBUTIONS/2016//NFVIFA(16)0001104r2_IFA022_NFVI_WAN_integration_analysis.docx
Status	For discussion
Relevance for T-NOVA	The ambition of ETSI NFV IFA022 includes clarifying the role of the WAN Infrastructure Manager module (WIM) and how it integrates and communicates with MANO functional blocks, as well as possible updates to existing MANO functional block roles and reference points. Unfortunately, as of January 2017, the document is still in a relatively incipient development stage, as only a number of use cases have been described but no clear conclusions have been reached about the role of ETSI NFV's WIM. In the absence of clear guidelines from ETSI NFV on this matter, T-NOVA decided to follow the pragmatic approach of defining, specifying and implementing the WICM module (the different naming is not incidental), in charge of E2E connectivity between service endpoints in VNFaaS scenarios. This includes not only the inter-NFVI-PoP component, but also the customer-VNF connectivity component. This contribution was a first attempt at bringing to IFA022 the experience, lessons learned and proposed solutions from T-NOVA. Decision on adopting the described technical approaches by IA022 was deferred until a later stage, after use cases have been defined, which did not happen before the end of 2016, at least. It is expected that during 2017 IFA022 reaches a level of maturity that enables the reactivation of the discussion around this contribution.

WG	IFA
Partner	Italtel
Title	NFVIFA(15)000450r5 IFA005 Virtual Links
Description	Contribution to ETSI GS IFA 005
Date	2015-05-22
Link	ETSI member only https://docbox.etsi.org//ISG/NFV/IFA/05-CONTRIBUTIONS/2015/001-to-999//NFVIFA(15)000405r5.docx
Status	For discussion
Relevance for T-NOVA	The discussion on Virtual Link is relevant considering several activities in T-NOVA and it is handled across different WPs. This contribution was presented for opening the discussion within the WG providing inputs according the T-NOVA requirements.

WG	IFA
Partner	Italtel
Title	NFVIFA(14)000502 VNFD restructuring – Monitoring aspects
Description	Contribution to ETSI GS IFA 011
Date	2015-05-22
Link	ETSI member only https://docbox.etsi.org//ISG/NFV/IFA/05-CONTRIBUTIONS/2015/001-to-999//NFVIFA(15)000502_VNFD_restructuring___Monitoring_aspects__.pptx
Status	For discussion
Relevance for T-NOVA	The discussion on VNFD is of paramount relevance for T-NOVA. This contribution was presented for opening the discussion on the monitoring aspects in VNFD.

WG	IFA
Partner	Italtel
Title	IFA010 section 6.3 VNF lifecycle management reqs – healing
Description	Contribution to ETSI GS IFA 010
Date	2015-03
Link	ETSI member only https://docbox.etsi.org//ISG/NFV/IFA/05-CONTRIBUTIONS/2015/001-to-999//NFVIFA(15)000350r3_IFA010_VNF_lifecycle_management_reqs_-_healing.docx
Status	For discussion
Relevance for T-NOVA	The discussion on VNFD is relevant for T-NOVA, in particular considering Task 5.3 - Development of Network Functions.

WG	IFA
Partner	Italtel
Title	IFA010 section 6.3 VNF lifecycle management reqs – migration
Description	Contribution to ETSI GS IFA 010
Date	2015-03
Link	ETSI member only https://docbox.etsi.org//ISG/NFV/IFA/05-CONTRIBUTIONS/2015/001-to-999//NFVIFA(15)000376r3_IFA010_VNF_lifecycle_management_reqs_-_migration.docx
Status	For discussion
Relevance for T-NOVA	The discussion on VNFD is relevant for T-NOVA, in particular considering Task 5.3 - Development of Network Functions.

WG	IFA
Partner	Italtel
Title	IFA001 Transcoding Use Case
Description	Contribution to ETSI GS IFA 001
Date	2015-05-22
Link	https://docbox.etsi.org/ISG/NFV/Open/Drafts/IFA001_Acceleration_-_UCs_report/
Status	Approved Contribution included in ETSI GS NFV IFA001.
Relevance for T-NOVA	The discussion on VNFD is relevant for T-NOVA, in particular considering the need to provide adequate performances in Task 5.3 - Development of Network Functions, specifically considering the implementation of Transcoding Units.

WG	IFA
Partner	Italtel
Title	IFA010 Multi-Tenancy Introduction and Requirements
Description	Contribution to ETSI GS IFA 010
Date	2015-07-01
Link	https://docbox.etsi.org/ISG/NFV/Open/Drafts/IFA010_MANO_Functional_Rqmts_Spec/
Status	Approved Contribution included in ETSI GS NFV IFA010.
Relevance for T-NOVA	The discussion on Multi-Tenancy is of paramount importance considering several activities in T-NOVA and in particular the implementation of the Marketplace.

WG	IFA
Partner	Italtel
Title	IFA005 and IFA006 Multi-tenancy
Description	Contribution to ETSI GS IFA 005 and IFA006
Date	2015-09-10
Link	Link (1): https://docbox.etsi.org/ISG/NFV/Open/Drafts/IFA005_Or-Vi_ref_point_Spec/ Link (2): https://docbox.etsi.org/ISG/NFV/Open/Drafts/IFA006_Vi-Vnfm_ref_point_Spec/
Status	Approved Contribution included in ETSI GS NFV IFA005. Contribution included in ETSI GS NFV IFA006.
Relevance for T-NOVA	The discussion on Multi-Tenancy is of paramount importance considering several activities in T-NOVA and in particular the implementation of the Marketplace.

WG	IFA, EVE
Partners	Atos, Italtel, NCSR Demokritos, PT PORTUGAL SGPS SA, TEIC l
Title	Feature Proposal: A Marketplace for NFV
Description	The present contribution proposes the feature "A Marketplace for NFV"
Date	2015-09-29
Link	http://wiki.t-nova.eu/tnovawiki/index.php/File:NFV(15)FTR029_Feature_proposal_A_Marketplace_for_NFV.docxAvailable on ETSI site
Status	The contribution was considered partially out of scope for the NFV ISG and it was suggested to reconsider it for TMForum.
Relevance for T-NOVA	The Marketplace concept was originally introduced with the T-NOVA project.

WG	IFA
Partner	Italtel
Title	IFA011 - Dependencies IE in the VNFD
Description	An Information Element describing the dependencies between VDU is requested since it describes constraints that affect the structure of a VNF..
Date	2016-05-19
Link	NFVIFA(16)000752_Dependencies_IE_in_the_VNFD_IFA011.docx
Status	Under discussion, not included in Release 3 due to the lack of time.
Relevance for T-NOVA	The discussion on the dependencies is important considering that a specific order may be requested in the instantiation of the VNF components.

WG	IFA
Partner	Italtel
Title	IFA011 - Metadata for VDUs in the VNFD
Description	The present contribution proposes the feature "A Marketplace for NFV"
Date	2016-05-19
Link	NFVIFA(16)000754_IFA011_-_Metadata_for_VDUs_in_the_VNFD.docx
Status	Under discussion, not included in Release 3 due to the lack of time.
Relevance for T-NOVA	The discussion on VDUs is needed for the decomposition of a VNF in VNFC according to the decomposed Software Architecture model.

WG	IFA
Partner	Italtel
Title	HA IE in the VNFD
Description	Definition of redundancy for High Availability.
Date	2016-05-19
Link	NFVIFA(16)000753_HA_IE_in_the_VNFD_IFA011.docx
Status	Under discussion, not included in Release 3 due to the lack of time.
Relevance for T-NOVA	The discussion on High Availability is of paramount importance for the deployment of VNF in the Service Providers networks.

WG	TST
Partner	Altice Labs, Atos, HPE, Italtel, NCSR Demokritos
Title	PoC_proposal_VNFaaS_e2e_ServOrc
Description	PoC proposal
Date	2016-08-03
Link	NFVTST(16)000094r2_PoC_proposal_VNFaaS_e2e_ServOrch.docx
Status	Accepted.
Relevance for T-NOVA	See the following section on ETSI PoC.

WG	TST
Partner	Altice Labs, Atos, HPE, Italtel, NCSR Demokritos
Title	PoC_40_Interim_Report_on_VNFaaS_e2e_ServOrch
Description	Interim report for the PoC.
Date	2017-01-18
Link	NFVTST(17)000014_PoC_40_Interim_Report_on_VNFaaS_e2e_ServOrch.docx
Status	A final report will be provided before the end of the project (March 2017)
Relevance for T-NOVA	See the following section on ETSI PoC.

7.2. IETF

WG	IETF (Network Working Group)
Partner	Primetel
Title	draft-pastor-i2nsf-merged-use-cases-00
Description	"Use Cases and Requirements for an Interface to Network Security Functions"
Date	June 26, 2015
Link	https://tools.ietf.org/html/draft-pastor-i2nsf-merged-use-cases-00
Status	Experimental

7.3. IRTF Network Function Virtualization Research Group (nfvrg)

WG	IRTF Network Function Virtualization Research Group (nfvrg)
Partner	NCSR Demokritos
Title	T-NOVA: Developing a platform for NfaaS
Description	Presentation at the IETF Meeting 91
Date	13/11/2014
Link	http://www.ietf.org/proceedings/91/slides/slides-91-nfvrg-7.pdf
Status	N/A

WG	IETF (Network Working Group)
Partner	NCSR Demokritos
Title	T-NOVA: Developing a platform for NfaaS
Description	Presentation at the Interim NFV RG Meeting - Austin,TX
Date	10/12/2014
Link	presentation (http://wiki.t-nova.eu/tnovawiki/index.php/File:Slides-Austin-Interim-nfvrg.pptx) and minutes (http://www.ietf.org/proceedings/interim/2014/12/10/nfvrg/minutes/minutes-interim-2014-nfvrg-2)
Status	N/A

7.4. OpenStack

WG	Openstack – TelcoWorkingGroup
Partner	PT PORTUGAL SGPS SA
Title	"Traffic Steering Abstraction for Neutron", blueprint
Description	PTIN has submitted a blueprint to OpenStack which is part of the Development Effort under the TelcoWorkingGroup. This working group aims to define the use cases and identify and prioritise the requirements which are needed to deploy, manage, and run telecommunication services (NFV) on top of OpenStack. The blueprint "Traffic Steering Abstraction for Neutron" provides an abstraction which can be used to realize service chaining.
Date	
Link	More info at https://blueprints.launchpad.net/neutron/+spec/traffic-steering-abstraction
Status	Accepted, later merged with other blueprint proposals. Formally, the present state of the original proposal is "Abandoned": https://review.openstack.org/#/c/92477

7.5. OPNFV

WG	Yardstick
Partner	Intel and NCSRD
Title	Project entitled "VNF Characterization Framework and Resources"
Description	Contribution of a fully characterized open source VNF (vTC), VNF Workload Characterization Framework which orchestrates the automated deployment and testing of VNFs based on OpenStack Heat templates and four test cases (TC1 – RFC2544 throughput, TC2 – Multi-tenancy CPU throughput, TC3 – Instantiation Validation, TC4 – Multi-tenancy Instantiation Validation). All three have been added to the Yardstick work program. Contributions are expected to be included in the OPNFV Brahmaputra release in Feb 2016).
Date	Feb 2016
Link	https://wiki.opnfv.org/yardstick
Status	In Progress

7.6. TMForum

WG	
Partner	Atos
Title	T-NOVA: A novel marketplace for NFV
Description	The specification of the implementation of T-NOVA Marketplace has been submitted in March 2016. T-NOVA Marketplace has been discussed in the context of a Red Discussion on on-boarding and an Open Source Community workshop held in Kista Stockholm (13th Oct), and it is listed now in the on-going action items planned to be discussed within R17.
Date	March 2016
Link	TMForum members only: https://projects.tmforum.org/jira/browse/ZOOM-46 https://projects.tmforum.org/wiki/display/ZOOM/2016-07-12+Zoom-wide+Q1,+Q2+-+HNWSaaP+Meeting+notes TMForum members only: https://projects.tmforum.org/wiki/display/ZOOM/R17+Candidate+Items
Status	In Progress
Relevance for T-NOVA	This contribution is an important output of the project. Due to the relevance of the standardization activities in TMForum it is the right opportunity for the full exploitation of the T-NOVA research.

WG	
Partner	Atos
Title	T-NOVA: A novel marketplace for NFV
Description	The T-NOVA Marketplace has been presented by Atos to the TMForum catalyst project Enabling Digital Marketplaces: Multi-SDO Metamodel for Discovery, Onboarding and Lifecycle Management
Date	December 2016
Link	
Status	In Progress
Relevance for T-NOVA	This initiative provides the possibility to introduce the T-NOVA Marketplace concept in a catalyst. Catalysts are proof-of-concept projects developed collaboratively by TM Forum members. In these projects different companies and service providers work together on innovative solutions demonstrating the value that can achieved. This gives the possibility to leverage TM Forum best practices and standards.

7.7. Other activities

Participation to ETSI NFV ISG meetings:

- ETSI NFV EVE WG meetings (ALB): on line
- ETSI NFV IFA WG meetings (ALB): on line;
- ETSI NFV IFA WG meetings (Italtel): on line;
- ETSI NFV Plenary meetings (Italtel): Malaga February 2014;
- ETSI NFV IFA WG meetings (Italtel): IFA meeting in Helsinki from 22 to 24 April 2015;
- ETSI NFV IFA WG meetings (Italtel): IFA meeting in Sophia Antipolis from 15 to 18 September 2015;

Tutorial on NFV Phase 2: File:Brief tutorial on ETSI ISG NFV Phase 2.pptx

Issues around ISG NFV, Feb-Mar 2015: File:Report of ETSI ISG NFV9 and beyond 25032015.pptx

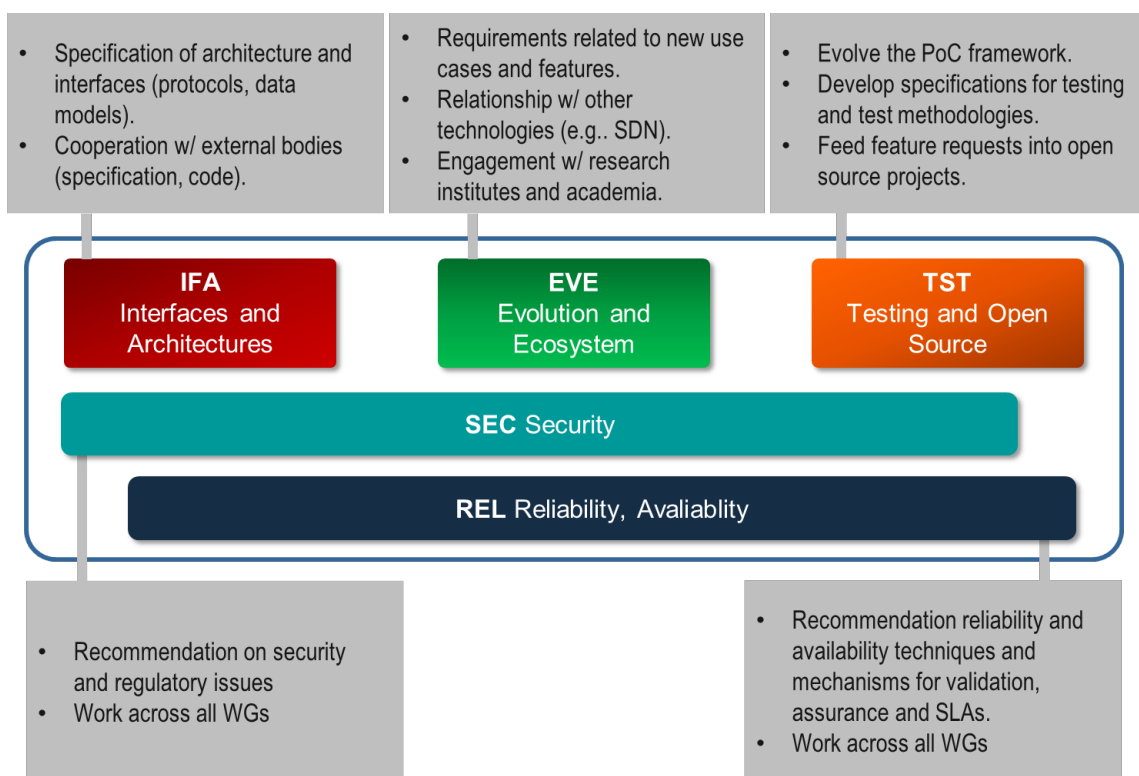The participation to the ETSI NFV meetings (ALB, Italtel) is related to the following work groups:

Figure 2 – Working groups in ETSI NFV ISG (Phase 2)

8. FUTURE WORK

The advantages of NFV over the use of dedicated infrastructures are multiple in terms of cost reduction, time-to-market reduction, flexibility, etc. However, NFV also brings a number of challenges that must be solved to enable its massive adoption in the market.

In particular, the first key point can be the promotion of innovation, by opening a part of the networking market and transforming it to a novel virtual appliance market, facilitating the involvement of software entrants, including SMEs and even academia and secondly the rapid introduction of novel network functions (including upgrading of existing ones) at much lower cost and lower risk, leading to significant decrease of Time-To-Market (TTM) for new solutions remain key issues in the NFV Market.

In order to facilitate the involvement of diverse actors in the NFV scene, an innovative "Virtual Network Function Marketplace" that can follow the paradigm of existing successful OS-specific "App Stores" is proposed by T-NOVA. The VNF Marketplace, which can be maintained by a Service provider, can contain VNFs created and provided by several third-party developers, published as independent entities and accompanied with the necessary metadata (including trading information as part of the VNFD). The Marketplace will allow customers to select the virtual appliances which best match their needs, "plug" them into their existing connectivity services and configure/adapt them according to their needs.

In order to facilitate competition and support different value chain configurations, a Brokerage Platform can also be established, allowing the Service Provider to transact with the multiple third-party Function Developers for selecting the best VNFs that suits their needs. Upon receiving the Service Provider request, the brokerage platform can examine i) the available Network and IT resources and ii) the available functions at the Function Store and come up with specific economic/technical offerings and associated billing models.

The marketplace allows network services and network functions by a variety of developers to be published and brokered/traded. Customers can browse the marketplace and select the services and virtual appliances that best match their needs, as well as negotiate the associated SLAs and billing models.

The main functionalities under investigation that can provide new possibility for contributions to the standards are described in the following sub sections.

8.1. Marketplace

The following items under investigation can provide the possibility to standardize the Marketplace:

- Publication of resources and advertisement. Through a customer front-end, third-party VNF developers advertise by describing their functions and customers can place their requests for services and virtual appliances.
- VNF discovery, trading. Through a brokerage module the SP can place their requests for VNFs and express requirements for their performance, receive

offerings and make the appropriate selections, taking into account the offered SLAs and pricing. Several billing models are considered such as pay –as you go, subscription and sharing revenue between SP and VNF developers.

▪ E2E Service offering description, including SLA specification and possible applicable rewarding based on SLA evaluation.

▪ Customer-side monitoring and configuration of the offered services and functions. End users, via a service dashboard, can interact with the Orchestrator platform for monitoring the status of the established services and associated NFs, as well as for performing – according to their associated permissions – management operations on them.

8.2. MANO

The following items are under investigation:

▪ VNFD: VNF descriptor;
▪ NSD: NS descriptor;
▪ Assurance: Failure notification and diagnostics for a VNFaaS that shall be provided to the final customer; Failure notification and diagnostics for a NFVIaaS that shall be provided to the customer accessing to the NFVIaaS;
▪ SLA management: For VNFs and NS that shall be provided to the final customer; For the provision of NFVIaaS that shall be provided to the customer accessing to the NFVIaaS;
▪ Accounting: Accounting of resource usage for VNFs and NSs; Inclusion of commercial agreements in VNFs and NSs; Commercial agreement between a SP and NFVI provider.

8.3. NFV Architecture

As far as the evolution of the reference architecture is concerned the following items are under investigation:

▪ Implementation of a Distributed NFVI with centralized data center and edge network data center distributed at the edge of the network;
▪ Placement of resources and VNFs according to network topology and service requirement (e.g. latency for real time communication) and minimizing the utilization of network resources;
▪ NFVIaaS: Separation of Service Provider role and NFVI provider role implementing the access to NFVI resources managed by a different entity;
▪ Evolution of the "Use Cases" including the possibility to make use of the Marketplace concept as an extension of the VNFaaS and NFVIaaS use cases with the separation of Service Provider role and NFVI provider role implementing the access to NFVI resources managed by a different entity.

8.4. SDN

The following items are under investigation:

- Adoption of SDN in the NFV architectural framework;
- Interconnection of different NFVI PoPs currently under discussion ETSI NFV 'DGR/NFV-IFA022' Work Item on the functional architecture necessary to manage and provision connectivity for multi-site NFV services (i.e. over WANs, access networks).

8.5. Security

The following items are under investigation:

- Evolution of the Security framework: Definition of security features allowing the secure instantiation of third party provided VNFs; Testing of security features of third party provided VNFs; Securing the access of a SP to a NFVI in case of NFVIaaS provision.
- Service Verification: Since external Function Providers will contribute the VNFs, service verification is required prior to offering via the Marketplace. The verification process could be on-line or off-line depending on the protocol used for verification by the Service Provider

8.6. Testing

The following items are under investigation:

- Evolution of the testing framework and Performance Evaluation: The performance of the VNFs made available through the Marketplace should be evaluated using actual deployment scenarios within the supported NFVI. In this context the SP should either allow a sandbox environment for Function Developers to evaluate the functionality and performance of their VNFs prior to allowing their uploading at the Marketplace.

8.7. NFV/WAN integration

Because T-NOVA (or any VNFaaS service, for that matter) is by definition composed of a network connectivity service and a set of associated network functions, integration of these two components is an essential requirement to guarantee successful deployment in a real scenario. The following items are under investigation:

- Deployment models for integration of WAN connectivity services and NFV infrastructure – centralized, distributed, decentralized;
- Connectivity between distributed NFVI resources for end-to-end service delivery; VNFaaS services with endpoints residing in multiple NFVI-POPs, interconnected by one or more WAN domains;
- Integration of emergent enterprise WAN solution (e.g. SD-WAN) and VNFaaS.

The first topic is being tackled by MEF ("Carrier Ethernet and NFV" White Paper,) and by ETSI NFV (IFA022 Work Item).

The second topic (strongly related to the first but mainly NFV-centric) was included in the ETSI NFV work programme for 2016 (IFA022).

In both cases, T-NOVA monitored the relevant activities contributing whenever considered relevant and appropriate.

In particular, considering IFA022, T-NOVA implemented a solution, for the WAN Infrastructure and Connectivity Manager (WICM), anticipating the completion of the ETSI standardization considering the the slow evolution in IFA011.

Strictly speaking, the third topic can be seen as outside the scope of T-NOVA, as originally defined, but represents a major evolution trend that has gained prominence in the industry and is likely to boost the impact of NFV and VNFaaS in enterprise environments. Therefore, relevant activity by SDOs in this area (e.g. IETF, ONF, ETSI NFV, MEF) were followed in the third year of T-NOVA.

9. POC AND IOT

This section describes the PoC and IoT performed with ETSI.

9.1. PoC

ETSI NFV ISG has developed an NFV PoC Framework to coordinate and promote multi-vendor Proofs of Concept illustrating key aspects of NFV ISG work and scoped around NFV use cases and architectural framework

T-NOVA is based on a new approach for the delivery of network functions and it was decided to provide an open demonstration in an ETSI NFV Proof of Concept (PoC).

The goal within the NFV ISG PoC Framework is to build awareness and confidence and to encourage the development of an open ecosystem by integrating components from different players.

T-NOVA PoC proposal was accepted as the ETSI NFV #40 PoC: "VNFaaS and end-to.end Service Orchestration".

A PoC Demonstration was performed at SDN & OpenFlow World Congress 2016, The Hague, October 11 – 14, 2016.

Eleni Trouva (Demokritos) described the PoC in her presentation: https://www.layer123.com/downloadnow&doc=NCSR_Demokritos-1016-Trouva-VNFaaS_with_end-to-end

The following video published on the Italtel YouTube channel was recorded at SDN & OpenFlow World Congress 2016: https://www.youtube.com/watch?v=EAXPZVoddGE

The PoCs help to identify gaps .in NFV standardization. The identified gaps were addressed with the contributions to the NFV ISG described in the specific chapter. The integration of VNFaaS with WAN connectivity, as demonstrated by Scenario 2, is not yet addressed by any ETSI NFV specification. A possible contribution to IFA022 on this matter is still under consideration.

The PoC can give origin to new Action Items and/or further work required from the NFV ISG and/or external forums.

Our considerations are the following: the standardization process is quite complex and we share a common vision but we still miss the precise definition of important protocol interfaces. On the other hand, we have "de facto" standards consolidated with the work of open source communities. We need an open ecosystem in order to overcome the current fragmented approach.

It is important to immediately focus on the basic interoperability between entities from different vendors, e.g. VNFs and MANO solutions, in order to orchestrate the creation of a wide catalogue of VNFs.

It is not important the definition of all the details, many are difficult to be implemented and can be rapidly overcome considering the evolution of the technologies.

The VNFaaS concept leverages a NFV Marketplace.

The relevance is based on the fact that "a market for mobile applications has been enabled by a much wider range of app developers than traditional Telecom equipment suppliers. Technologies such as NFV and SDN may lead to similar markets for network apps". (Open Source and Standards, Wright, Druta Globecom 2014).

The PoC team believes that this approach can foster innovation in the NFV environments allowing to extend the NFV ecosystem by including independent software providers. In addition, the uptake of NFV technology can be accelerated by VNFaaS, as potential benefits to all involved stakeholders (Service Providers, Function Providers, Customers) are enabled.

At now Service Providers are focused on the application of NFV for existing applications, pursuing "cost reductions", "operational efficiency". If we look at the implemented use cases, we can see an approach focused on cost reductions with the possibility to gain operational efficiency. Telcos are approaching the new technologies trying to benefit from the optimization of their networks in order to achieve capital expenditures reduction, operational efficiency and business agility but it is interesting to analyze the possible broadening of the reference market in order to generate new revenues.

The VNFaaS concept provides the possibility to extend the application of NFV introducing new solutions.

It opens the possibility to have new entrants as VNF Providers in a market dominated by incumbent vendors including the use of open source solutions for implementing network services and generally facilitating innovation.

New business models can be established thanks to the marketplaces, paving the way to a great deal of new available solutions that can be provided with new agile procurement practices.

9.2. Interoperability Testing

The first NFV Plugtests event is planned from 23 January to 3 February 2017, hosted by 5TONIC Laboratory in Leganes, near Madrid, Spain.

The event is organized by the ETSI Centre for Testing and Interoperability. Italtel is participating with the vSBC VNF.

The NFV Plugtests event allows to perform test sessions where vendors and Open Source projects can assess the level of interoperability of their implementations and verify the correct interpretation of the ETSI NFV specifications.

This activity is supported by the European Commission.

10. CONCLUSION

This deliverable (D8.22: final report on standardisation) is a final report providing information on the standardization activities of the T-NOVA project and the progress within standardization groups and contributions submitted on behalf of the project.

Activities towards the standardization of the project results were explored in WP8 in order for T-NOVA to have the maximum possible impact both in the scientific and industrial/commercial communities.

11. LIST OF ACRONYMS

Acronym	Description
API	Application Programming Interface
COTS	Commercial-off-the-shelf
DC	Data Center
DMTF	Distributed Management Task Force
DPDK	Data Packet Development Kit
ETSI	European Telecommunications Standards Institute
EU	European Union
HGI	Home Gateway Initiative
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPR	Intellectual Property Rights
ISG	Industry Specifications Group
ISO	Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
KVM	Kernel-based Virtual Machine
MANO	Management and Orchestration
MEF	Metro Ethernet Forum
NCSR	National Centre for Scientific Research
NFaaS	Network Functions-as-a-Service
NF	Network Function
NFV	Network Functions Virtualization
OCCI	Open Cloud Computing Interface
ONF	Open Networking Foundation
OSS	Open Source Software
SDN	Software Defined Networking
SLA	Service Level Agreement
SDO	Standard Definition Organization
SW	Software
SWA	Software Architecture
UML	Unified Modelling Language
VNF	Virtualized Network Function
WAN	Wide-Area Network
WP	Workpackage
WPL	Workpackage Leader

12. REFERENCES

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[NFVRG]   https://trac.tools.ietf.org/group/irtf/trac/wiki/nfvrg

[SDNRG]   https://trac.tools.ietf.org/group/irtf/trac/wiki/sdnrg

[ISO]   http://www.iso.org/

[ONF]   https://www.opennetworking.org/

[MEF]   https://metroethernetforum.org/

[TMFORUM]   http://www.tmforum.org/zoom/

[OS]   https://www.openstack.org/

[ODL]   http://www.opendaylight.org/

[OPNFV]   https://www.opnfv.org/

[HGI]   http://www.homegatewayinitiative.org/