TNOVA

NETWORK FUNCTIONS AS-A-SERVICE
OVER VIRTUALISED INFRASTRUCTURES

GRANT AGREEMENT NO.: 619520

Deliverable D8.4

Final Report on Training Activities

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Executive Summary

This document presents an overview of the training activities that took place towards sharing T-NOVA's outcomes to all interested parties and familiarise its potential users with the project's toolkits and technologies.

Overall, six training activities were carried out since the project's beginning, including two summer schools, two online demos, one book chapter and one postgraduate e-course.

Moreover, significant training material, in the form of instructions and how-to's, was published in GitHub, accompanying the project's open-source components, with the aim to enable the community to install, use and possibly integrate them in other experimental testbeds.

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1. INTRODUCTION

1.1. Objectives and scope

This deliverable presents the outcomes of Task 8.4 (Training activities), namely the production and publication of educational materials and their consequent exploitation in training activities that were promoting both the diffusion of T-NOVA's results to a greater audience and the familiarisation of its potential users with the project's toolkit and methodology. Significant educational material was made available via the GitHub platform, for reasons of efficiency in managing, maintaining and deploying the open sourced T-NOVA modules. As far as it concerns the training activities, the effort was focused on creating training content in various forms including presentations, videos and tutorials (e.g. book chapter and standard howtos). The produced material was used in several training activities such as summer schools, online demos and one e-course.

1.2. Document structure

This report is structured as follows:

Section 1 provides the objective, scope and structure of this report.

Section 2 presents the training activities that took place since the project's beginning.

Section 3 presents the information available in GitHub

Finally, section 4 summarises the report.

2. TRAINING ACTIVITIES

2.1. Introduction

In this section, the training activities that were carried out since the project's beginning are presented. These activities were aiming not only to diffuse T-NOVA's outcomes to a greater audience but also to habituate its potential users with the project's tools and functions (e.g. Marketplace). At the below table an overview of the performed training activities is presented whereas a more detailed description is given at the following sections.

Activity	Type	Link
1	Summer school	https://aegeannetcom2016.pns.aegean.gr/
2	Summer school	https://blog.zhaw.ch/icclab/cloud-computing-summer-school-2016-highlights/
3	Howtos, Book Chapter	https://github.com/T-NOVA, http://www.theiet.org/resources/books/telecom/coudfog.cfm (Chapter 14)
4	Demo	https://www.youtube.com/watch?v=q0j3yTu27Is
5	e-course	https://eclass.teicrete.gr/courses/TP291/
6	Demo	https://www.youtube.com/watch?v=EAXPZVoddGE

Table 1 Overview of Training Activities

2.2. 1st Training Activity

2.2.1. Description

The first activity took place during the "2nd International Summer School on Emerging Architectures and Key Technologies for 5G Networks" (https://aegeannetcom2016.pns.aegean.gr/), held in 29th Aug – 2nd Sept 2016 in Samos island, Greece. The summer school was organized by the University of the Aegean and supported by TEIC.

The program was designed for senior undergraduate and graduate students (already enrolled in a MSc/PhD program) from Universities in Greece and abroad in the fields of electrical engineering, electronic engineering, communication and networking engineering and related disciplines. In addition to that, young and senior professionals that wish to specialize or update their knowledge in the areas of communication and networking, were also welcome to join. In the following six weeks after the summer's school ending, the participants had to write a report (about

5000-7000 words) on a specific subject. The report was obligatory for receiving 3 ECTS credits; otherwise 2 ECTS were validated.

During the allocated slot times, presenters from TEIC provided an overview of the key technologies that T-NOVA built upon, namely Virtualisation, Software-Defined Networking (SDN) and Network Functions Virtualisation (NFV). Following that, T-NoVA architecture and key modules were presented focusing, mainly, on T-NOVA's Marketplace and VNF Framework. Finally, a lab session was carried out where the trainees were given the task of connecting to the Marketplace and creating and instantiating their own VNFs and services.

Figure 1 Presenting T-NOVA Marketplace at aegeannetcom2016 summer school

Figure 2 aegeannetcom2016 Summer School's Participants

2.2.2. T-NOVA Components involved

The training sessions during the summer school focused on the following T-NOVA components:

- Marketplace
- VNF Configuration and deployment

2.3. 2nd Training Activity

2.3.1. Description

A second training session took place during the ZHAW Cloud Computing Summer School 2016 (https://blog.zhaw.ch/icclab/cloud-computing-summer-school-2016-highlights/).

Summer School is a yearly activity at ZHAW, organised in the first 2 weeks of July, in collaboration with the Grand Valley State University (GVSU), USA.

Students of both universities attend the lectures in Winterthur. Swiss students are given the option to attend 2 complimentary weeks in the USA right after the Summer School in Winterthur. The program was slightly changed this year by introducing guest lecturers. In the previous years all lectures were given by the SE group members, which we modified this year by inviting known experts in the field of Cloud Computing from Switzerland and abroad, to talk about the current technologies as well as the current practices in their organisation. This mix of academic and applied modules was very well received by the students.

The content taken in the school were inspired by the research outcome of ICCLab's engagement in EU projects such as MCN, FIWARE, **T-NOVA** and SESAME.

Figure 3 ZHAW Summer School's Participants

2.3.2. T-NOVA Components involved

The training sessions during the summer school focused on the following T-NOVA components:

- SDN
- Service function chaining

2.4. 3rd Training Activity

2.4.1. Description

A Book chapter was written to explain in details the Brokering and auctioning processes inside the T-NOVA Marketplace. The book is targeting a wide audience in the 5G domain, raising awareness about the T-NOVA Marketplace solution.

The book is entitled: "Cloud and Fog Computing in 5G Mobile Networks: Emerging Advances and Applications", the editors are E.Markakis, G. Mastorakis, C.X. Mavromoustakis, E. Pallis. (TEIC) and is expected to be published end of March by the Institution of Engineering and Technology(The IET).

The book contents are available at:

http://www.theiet.org/resources/books/telecom/coudfog.cfm

T-NOVA is described in Chapter 14: A Novel Marketplace for Trading/Brokering Virtual Network Functions over Cloud Infrastructures - *George Alexiou, Evangelos Pallis, George Mastorakis, Evangelos Markakis, Anargyros Sideris, Athina Bourdena, Constandinos X. Mavromoustakis*

2.4.2. T-NOVA Components involved

The book chapter focused mainly on the following T-NOVA components:

- Marketplace
- Auctioning
- Broker

2.5. 4th Training Activity

2.5.1. Description

NCSRD and SPH, with the assistance of other involved partners, produced a tutorial video of the T-NOVA MANO system (TeNOR Orchestrator & Marketplace), explaining how the platform can be used for the handling the lifecycle of an NFV (Network Functions Virtualisation) service, from VNF onboarding and service creation to service deployment and monitoring.

The video was published to YouTube and is available at https://www.youtube.com/watch?v=q0j3yTu27Is

2.5.2. T-NOVA Components involved

The tutorial video focused on the operation, from a user's point of view, of the following components:

- Marketplace and VNF Configuration
- TeNOR Orchestrator

2.6. 5th Training Activity

2.6.1. Description

Tutorials focusing on T-NOVA were also a part of TEIC Post-Graduate and Open Lessons on next-generation networking.

In general, the course aimed to provide an understanding of fundamental concepts, as well as advanced research topics on Computer Networks with an emphasis on

modern TCP/IP networks. The course includes a theoretical and a practical part that elaborates further on practical issues of TCP/IP networking and administration. The course also deals with advanced research issues related to TCP/IP networking of special interest to the instructors but of great research and practical interest to the industry too. The methodology exploits pedagogical and didactical approaches based on recent advances in computer networks as those presented and analysed in selected journal publications and conference papers, aiming to delve into state-of-the-art concepts, besides enabling students to collaboratively work on projects that will be submitted and evaluated during the semester.

The link to the course is https://eclass.teicrete.gr/courses/TP291/ (access upon registration only).

Figure 4 Dr. E. Markakis (TEIC) Presenting SDN Theory.

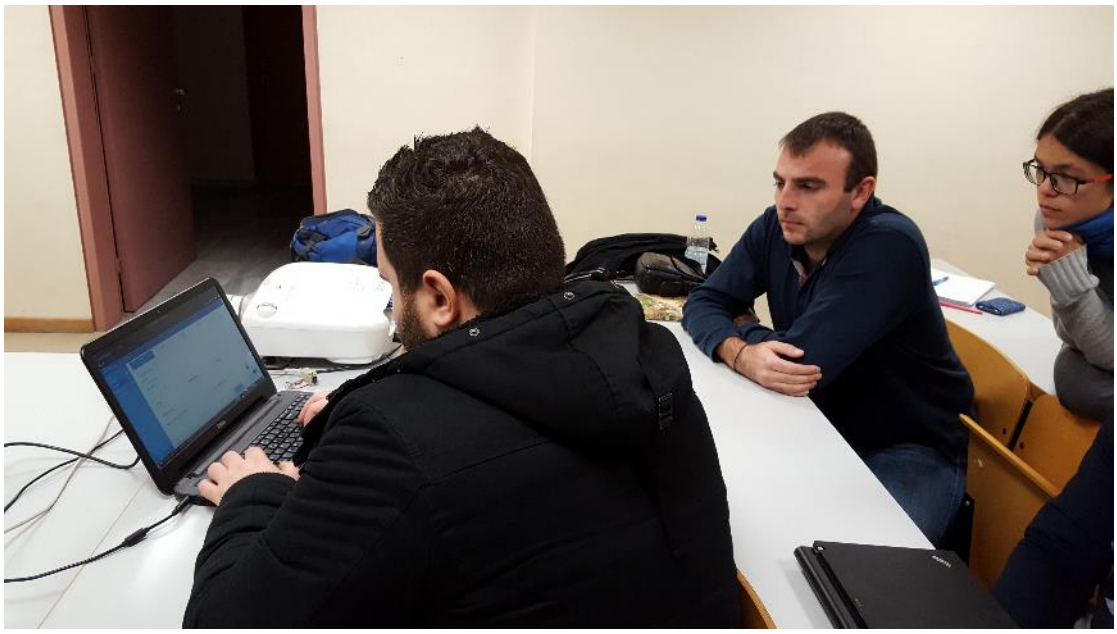

Figure 5 Mr. E. Alexiou (TEIC) training post-graduates student to T-NOVA Marketplace

2.6.2. T-NOVA Components involved

During the course, students were presented/trained on the following T-NOVA components:

- Marketplace
- Service Function Chaining
- TEIC Testbed
- SDN Theory+Lab
- IPv6+QoS Techniques
- Fog Networking

2.7. 6th Training Activity

2.7.1. Description

NCSRD presented a tutorial demo as part of the ETSI PoC #40 "VNFaaS with end-to-end full service orchestration" performed by Eleni Trouva (NCSRD) at EWSDN and SDN & OpenFlow World Congress 2016, The Hague, October 11 - 14, 2016.

The short presentation of the demo was shown to all people attending the demo session of the fifth edition of the European Workshop on Software Defined Networks (EWSDN) that took place in the Hague, Netherlands. Researchers from universities, research centers and industry were present in the event. Most the people were employed in the industry sector, as the event was co-located with the SDN World Congress 2016 which was organized by Layer123. The live demo was demonstrated after the presentation to all people interested in the T-NOVA project. Most received

questions during the demonstration were concerning the T-NOVA NFV Orchestrator (TeNOR) and the Marketplace implementation and functionalities. Project's leaflets and contact information were given to those people that attended the live demo.

The tutorial has been edited in a video, published on YouTube: https://www.youtube.com/watch?v=EAXPZVoddGE

2.7.2. T-NOVA Components involved

The tutorial demo focused on the following components of the T-NOVA system:

- Marketplace (both SP and FP views)
- TeNOR NFV orchestrator
- PxaaS VNF
- Monitoring Framework
- NFVI deployment (OpenStack)

3. T-NOVA TUTORIALS ON GITHUB

3.1. Introduction

As T-NOVA has committed to open-sourcing most of its results, extensive tutorials were published in GitHub, accompanying the software and providing the ability to the global community install and work with T-NOVA open source modules.

The material available through the T-NOVA GitHub account, is as follows:

3.2. ProXy as a Service (PXaaS) virtual Network Function (vNF)

Content available at: https://github.com/T-NOVA/proxy-build

3.2.1. Squid-Dashboard

Content available at: https://github.com/T-NOVA/Squid-dashboard

3.2.2. Dashboard for the PXaaS VNF

Content available at: https://github.com/T-NOVA/Squid-dashboard

3.2.3. PXaaS-monitoring

Content available at: https://github.com/T-NOVA/PXaaS-monitoring

3.3. Virtual Security Appliance (vSA) VNF

Content available at: https://github.com/T-NOVA/vSA

3.4. Virtual Traffic Classifier VNF

Content available at https://github.com/T-NOVA/vTC

3.5. TeNOR NFV Orchestrator

Content available at: https://github.com/T-NOVA/TeNOR

3.6. WICM WAN Infrastructure and Connectivity Manager

Content available at: https://github.com/T-NOVA/WICM

3.7. Marketplace

Content available at: https://github.com/T-NOVA/Marketplace/tree/master/marketplace

3.8. NFV descriptors

Content available at: https://github.com/T-NOVA/NFVdescriptors

3.9. VIM monitoring backend

Content available at: https://github.com/T-NOVA/vim-monitoring

3.10. Network Function Store server

Content available at https://github.com/T-NOVA/NFS

3.11. Cyclops billing-charging framework

Content available at https://github.com/T-NOVA/cyclops

4. CONCLUSIONS

T-NOVA undertook diverse training activities in order to familiarize all interested stakeholders with the operation of the project platform and individual components. These activities mainly targeted at the technical/scientific community as well as postgraduate/PhD students. Adopting the principle of life-long learning and ongoing training all of the training material is available online (see links at the corresponding sections of chapter 2).

5. List of Acronyms

Acronym	Explanation
FP	Function Provider
NCSRD	NCSR "Demokritos"
NFV	Network Functions Virtualisation
NFVI	NFV Infrastructure
PXaaS	Proxy as-a-Service
SDN	Software-Defined Networking
SP	Service Provider
TEIC	TEI of Crete
VNF	Virtual Network Function
ZHAW	Zurich School of Applied Sciences